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Technical Report 671

Acquisition and Retention of Soldiering Skills

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AD-A160 336

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Research Institute for the Behavioral and Social Sciences

February 1985

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REPORT DOCUMENTATION PAGE

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1. REPORT NUMBER: ARI Technical Report 671	2. GOVT ACCESSION NO. AD-A160 336
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle): ACQUISITION AND RETENTION OF SOLDIERING SKILLS	5. TYPE OF REPORT & PERIOD COVERED: Final Report January 1983-September 1984
6. PERFORMING ORG. REPORT NUMBER: AIR FR88600	
7. AUTHOR(s): Andrew M. Rose, Mark Y. Czarnolewski, Frances E. Gragg, Stuart H. Austin, Patrick Ford (HumRRO), Jack Doyle (HumRRO), Joseph D. Hagman (ARI)	8. CONTRACT OR GRANT NUMBER(s): MDA 903-81-C-AA01
9. PERFORMING ORGANIZATION NAME AND ADDRESS: American Institutes for Research, 1055 Thomas Jefferson Street, NW, Washington, DC 20007	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: 63743A, 2Q263743A794, 5329 332
11. CONTROLLING OFFICE NAME AND ADDRESS: U.S. Army Research Institute for the Behavioral and Social Sciences, 5001 Eisenhower Avenue, Alexandria, VA 22333-5600	12. REPORT DATE: February 1985
	13. NUMBER OF PAGES: 141
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office): --	15. SECURITY CLASS. (of this report): Unclassified
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE: --

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

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18. SUPPLEMENTARY NOTES

John R. Hayes, Contracting Officer's Representative. User's Manual published separately as ARI Research Product 85-13.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Skill acquisition	Skill maintenance	Task classification
Skill retention	Task proficiency	Scheduling of training
Task acquisition	Skill proficiency	
Task retention	Task difficulty	

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

To provide effective training within fixed time and resource constraints, unit commanders and trainers must have reliable information on which soldiers need training, on which tasks should be trained, and on when training should be scheduled. The key to providing such information is a method that generates estimates of unit retention of proficiency in individual tasks during intervals of no practice. With such a method, unit commanders and trainers should be able to organize training schedules that optimize unit readiness.

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20. (Continued)

The goal of this project has been to develop such a method. The User's Decision Aid (UDA) allows the trainer to estimate task proficiency levels at a particular time and project the rate of proficiency loss over a 12-month interval. The UDA was developed from, and validated against, actual retention data collected from soldiers serving in several Military Occupational Specialties (63N, 11B, 13B), and performing many different tasks.

The UDA requires the user to answer a series of questions about the characteristics of tasks that have been shown to be related to their retention. Following the completion of the ratings, the user calculates a summary score which is converted to a unit proficiency estimate via a table look-up procedure. The UDA exists in both a paper-and-pencil and a computerized version, with the latter version suitable for implementation on an Apple microcomputer.

This report reviews the 3 years of the project, with particular attention to the Year III examination of acquisition and retention data collected from soldiers in MOS 13B.

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Office, Deputy Chief of Staff for Personnel
Department of the Army

February 1985

Army Project Number
2Q263743A794

Education and Training

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FOREWORD

The decline in performance caused by forgetting tasks is a critical training problem in the Army. One of the trainer's primary responsibilities is to ensure that his or her soldiers remain proficient on tasks they have already learned. This means conducting periodic refresher training since soldiers forget tasks not practiced in the unit on a regular basis. Unfortunately, unit training resources are scarce, and no method has been available for helping the trainer identify tasks that either have been, or are about to be, forgotten. Without such information it is difficult to target refresher training effectively, and thereby obtain maximum payoff from the limited training resources available.

In response to this need, the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) has developed an easy-to-use method for predicting how rapidly individual tasks will be forgotten over intervals of no practice extending up to 1 year. The method has been developed in both paper-and-pencil and computer-based format and is geared to help trainers decide what tasks are most likely to be forgotten, how many soldiers will be able to perform a task correctly at any point in time, and when and how often refresher training should be conducted.

This report describes the results of research performed over the past 3 years to support development of this method.

Edgar M. Johnson
Technical Director

ACKNOWLEDGMENTS

We collected data in the Seventh Division at Fort Ord, California. The Division Artillery S-3 (Tasking) Office coordinated support for the project. CPT Cobb was primarily responsible for arranging the support.

The data collection effort was marked by the extraordinary cooperation of the 2nd Battalion, 8th Field Artillery under the command of LT COL John Truesdale. While people throughout the battalion supported the project, three people deserve special mention. CPT Cole, Battery Commander of C Battery, was responsible for providing well-maintained equipment on a tight schedule. MSG Hern and, later, MSG Walters (Tasking) coordinated the personnel support. Mr. Sammie Wright was first assigned to the project as an NCO scorer. When he terminated service he consented to work as a civilian scorer. He also provided valuable assistance in coordinating support for the retention phases.

Six other civilians worked on a part-time basis to collect the data. These highly competent men were:

Scott Stout	Charles Briggs
Danny Finn	Gary Ford
Milland Hodge	Earl Wilson

Six NCOs from the 2/8 Battalion also administered tests and conducted training:

SGT Alvin Strickland	SGT Conrad Deleon
SGT Rickey Rhodes	SSG Karl Lattimore
SGT Robert Little	SSG Larry Smith

As in the previous 2 years, the project was fortunate in the quality of the soldiers who were made available for testing. The young men in MOS 13B, assigned to the 2/8 Battalion, distinguished themselves through their high level of discipline and cooperation.

ACQUISITION AND RETENTION OF SOLDIERING SKILLS

EXECUTIVE SUMMARY

Requirement:

To develop and validate a convenient, practical method that individual unit commanders and training managers can use when deciding how to allocate training resources in order to maximize combat readiness.

Procedure:

This report describes the third and final year of a 3-year effort. Previous project accomplishments are briefly reviewed, and activities associated with the third year of effort are described in detail. These Year III activities include: (1) a field experiment of acquisition and retention performance of Field Artillery tasks, using soldiers in MOS 13B. Approximately 140 soldiers were trained on 22 tasks and tested for recall at 2-month intervals. Also, the effects of overtraining, previous testing, and soldier abilities (i.e., ASVAB composite scores) were examined. (2) The development of a User's Decision Aid, which uses ratings of task characteristics to estimate retention functions for each task. (3) The assessment of the relationship between the predicted and empirically obtained retention functions.

Findings:

Results indicated that it was possible to estimate soldiers' proficiency accurately over time, using the User's Decision Aid ratings. Correlations between actual retention performance and proficiency levels estimated by UDA were in the range of $r = 0.90$. Soldier abilities and overtraining were not systematically related to performance.

Utilization of Findings:

Applications of the User's Decision Aid to estimate proficiency levels over time could prove useful in several ways. Short- and long-term scheduling of training and refresher training could be improved. The User's Decision Aid could be integrated into existing Battalion Training Management Systems.

ACQUISITION AND RETENTION OF SOLDIERING SKILLS

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I. INTRODUCTION

A major function of the Army is to train and maintain combat-ready troops. Providing effective training within resource constraints of the unit requires unit commanders and training managers to answer several questions. Which soldiers need training? Which tasks need to be trained? When should training be scheduled? How much training will be required?

Performance on any task declines if the task is not practiced periodically. In addition, different tasks have different rates of forgetting (Schendel, Shields, & Katz, 1978; Hagman & Rose, 1983). Thus, effective training management requires identification of tasks most likely to be forgotten and those least likely to be retained in order to obtain maximum payoff for the resources spent.

It is not feasible to test large numbers of soldiers on each Army task to find out the rates of performance deterioration associated every task. However, one can use theoretical and empirical research to identify categories of tasks most likely to require frequent or infrequent training to maintain proficiency.

Identification of these task characteristics was the goal of this project. Our intent was to produce a convenient, practical method that individual unit commanders and training managers could use when deciding how to allocate training resources in order to maximize combat readiness. In addition, we wanted to examine the effects on retention of several moderating variables, such as soldier ability and practice.

Four specific objectives of the project were identified:

- to determine task characteristics that influence acquisition and retention;
- to determine the effects of moderating variables such as soldier ability and practice;
- to develop a method for predicting individual task retention; and
- to package this information into a format that Army personnel could use to assess training needs and to increase training effectiveness within the unit.

Our approach for meeting these specific objectives consisted of several tasks. First, we reviewed experimental and theoretical literature concerning acquisition and retention for different tasks, soldiers, and time intervals. Second, we developed a Task Classification System (TCS) that categorized tasks on the basis of task dimensions related to retention. This TCS formed the core of the User's Decision Aid (UDA), a systematic rating procedure and algorithm that generates predictions of soldier proficiency levels over time. Third, we conducted a series of field experiments to obtain data for validating predicted retention loss rates for different kinds of tasks in several Military Occupational Specialties (MOSs).

This report (a) reviews and summarizes the tasks conducted and the results achieved during the first two years of the project, and (b) describes in detail the activities associated with the project's third and final year.

Summary of Year I and Year II Results

Year I

The first year of research was devoted to three major tasks: (1) conducting a literature review; (2) beginning the development of the Task Classification System (TCS); and (3) collecting performance data in the field on a sample of military tasks (Rose & Ford, 1982).

Literature review. Journal articles and technical reports pertaining to acquisition and retention were reviewed, with the focus on those projects conducted or supported by the Army Research Institute (ARI), using Army tasks performed in Army settings.

Several of the ARI projects investigated training variables that influence task retention. The results of these projects showed that: (a) overtraining improved task retention; (b) inclusion of additional test trials and the spacing of repetitions during training were effective in promoting retention; and (c) innovative instructional techniques such as the use of mnemonics could enhance retention under some conditions.

Task characteristics that were investigated included difficulty, interstep cueing, step "relevance" (i.e., its perceived connection to the task), and required number of steps. These characteristics also were found to affect task retention.

Several ARI projects addressed the question of predicting retention from individual ability measures (e.g., Armed Forces Qualification Test [AFQT] and Armed Services

Vocational Aptitude Battery [ASVAB] scores). While the findings from these projects were difficult to interpret, there was consensus that level of soldier ability was related to retention of skilled performance.

The literature review had several implications for other segments of this project. It directed our attention to certain variables whose relationship to acquisition and retention clearly needed further empirical study. These variables -- training strategy, individual soldier differences, task characteristics, and practice -- formed the set of independent variables underlying our field data collection effort. Furthermore, the literature review helped to reveal a set of task characteristics presumed to be related to retention; the TCS was structured around many of these characteristics (Rose, McLaughlin, Felker, & Hagman, 1981).

Task Classification System. During Year I, we constructed a preliminary TCS based on the results of the literature review, and then evaluated it. Construction of the TCS involved specifying task characteristics, operationalizing their definitions, developing rating scales and anchor points, and determining scale weights and combination rules.

At the end of Year I, the TCS contained 11 dimensions related to military task performance. These dimensions were organized into three general categories:

- Enabling Skills: skills that are adjunct to the task but that enable it to be performed (e.g., "Use of Auxiliary Equipment");
- Task Characteristics: the steps required for task performance, the relationships among steps, and the information-processing requirements of steps (e.g., "Number of Steps"); and
- Criterion Characteristics: the performance criteria (e.g., "Consequences of Effort") (Rose, Allen, & Johnson, 1982).

Data collection. Data were collected in the field to determine the effects of variables indicated in the literature to be important determinants of task retention: length of no-practice interval, soldier ability, degree of initial learning, and task characteristics. In our initial field work, we collected acquisition, retention, and relearning data for a sample of tasks performed by Track Vehicle Mechanics, MOS 63N.

The general approach for data collection was to administer and score hands-on tests. Each mechanic was tested on six tasks in two different sessions. During the first session (i.e., the Acquisition phase), mechanics were tested and scored on the tasks, given feedback regarding accuracy, and then asked to repeat the task until they achieved proficiency (i.e., one correct performance). They then received extra training on half the tasks, consisting of two extra "test-feedback-retest" cycles; that is, each soldier was tested and scored, given feedback, and retested until he performed the task correctly twice more. We called this "mastery" training. The second session (i.e., the Retention phase) occurred about two months later. The same hands-on tests were given again to determine retention. Following the retention test, mechanics relearned each task back to proficiency criterion levels.

The general picture of acquisition and retention performance was as follows:

(1) **Acquisition** - Performance was scored in three ways: number of steps GO, percentage of mechanics GO (i.e., performing a task without errors), and task performance time. We assessed the acquisition function for each task: number of steps GO increased for all tasks from the first to the second repetition, where almost perfect performance was reached. Similarly, time to perform each task decreased with practice during the first session.

(2) **Retention** - At the Retention phase, there was little or no forgetting in terms of number of steps performed correctly for any task after two months of no practice. Performance was virtually perfect, with a mean of less than one error per task. A slightly different picture emerged for the percentage-of-mechanics GO measure: on this measure, there were retention losses for some tasks for both the mastery and proficiency groups of mechanics.

Retention performance for the time measure showed forgetting: time to complete a task increased substantially for all tasks. This retention loss was not systematic across tasks; while performance for all tasks slowed down compared to the last trial of Acquisition, performance on some tasks slowed down more than on others.

Retention performance was not related systematically to soldier ability, as measured by ASVAB or AFQT scores. Also, retention performance was not related systematically to degree of original learning (i.e., proficiency vs. mastery). Furthermore, there were no interactions among the major experimental variables (degree of original learning, ability, and retention interval).

With regard to relearning, there were no systematic effects related to ability or task differences. This was due to lack of variance: relearning of all tasks was virtually complete within two trials.

The key to understanding these results lies in the fact that performance in the 63N MOS is aided by technical manuals (TMs). Mechanics used these manuals while performing all tasks. Thus, all a mechanic needed to do was follow the manual to perform the tested task. The sole sources of errors would be ambiguities or deficiencies in the TMs themselves or the mechanic's lack of familiarity with specific tools.

One further assumption accounted for practically all of the results: performance of 63N tasks is normally untimed (i.e., there are no prescribed time limits). We speculated that mechanics "took their time and did it right" during the retention test, thus accounting for the slower performance times.

These results did not shed much light on variables affecting acquisition and retention of skills, other than to indicate the importance of job aids. Thus, the focus of Year II data collection was on acquisition and retention of tasks that were not job aided.

Year II: Data Collection

A major activity during Year II was the collection of acquisition and retention data for a sample of 18 MOS 11B10 (Infantryman) tasks (Rose, Manning, Radtke, & Ford, 1983). We selected tasks meeting four criteria: the task was contained in the 11B Skill Level 1 Soldier's Manual (SM); the task was not going to be included in the 11B Skill Qualification Test (SQT) hands-on component, SQT skill component, or Expert Infantry Badge (EIB) tests; the logistic demands for the task could fit our administrative requirements; and the tasks would sample a range of task characteristics identified in the TCS.

We developed a hands-on test for each of the 18 tasks. Each test consisted of a scoresheet and administrative instructions. Administrative instructions followed the same format as SQT hands-on tests.

Data collection. Data were collected in four phases. During the first "Acquisition" phase, 165 soldiers were tested and trained on all tasks. Hands-on tests covering the selected tasks were administered first during the Acquisition phase. If a soldier failed a task, the scorer told him each step performed incorrectly and demonstrated steps if necessary. After this training, the soldier performed the

task again, and the process was repeated until he performed the task without error.

After being tested and trained on all tasks, each soldier received "Mastery" training on half of the tasks. That is, after completing all the tasks once correctly, each soldier returned to half of the stations, where he repeated each task until it was performed without error; this "repeat cycle" was done twice so that each soldier completed three errorless performances on half of the tasks.

During the second phase, about two months later, we tested one-third of the soldiers on all the tasks. During the third phase, four months after Acquisition, we tested the soldiers from Phase Two and another one-third of the original group. Soldiers tested at the two-month and four-month retention intervals performed each task one time with no assistance or feedback. Scorers were told not to give soldiers any information about their overall performance ("GO" or "NO-GO") or about specific steps. During Phase Four, six months after Acquisition, we tested and retrained all soldiers in the project. No retraining occurred during the second and third phases.

Scorers conducted the six-month retention test the same way they conducted the initial Acquisition test. If the soldier made a mistake, the scorer told him what the mistake was and had him do the task over. The scorer also recorded the number of trials the soldier needed before he was able to do the task without error.

Results. In general, soldiers did well on first-trial acquisition performance measures on tasks requiring primarily physical, as opposed to primarily mental or verbal activity. Soldiers did not do as well on tasks that required processing of verbal information, performance of complex procedures, or decision making. More trials were typically required to learn these latter tasks.

From an analysis of the retention data, all tasks showed forgetting after two months. Retention losses for mental tasks were dramatic. During the two-month test, no soldier could correctly name vehicles, and very few could identify vehicles as friend or foe. On the other hand, performance was quite good on some physical tasks. Between the two-month and four-month Phases, performance declined on most of the mental tasks, while for most physical tasks, performance remained about the same between the two phases.

The descriptive statistics for the six-month retention test showed a dramatic increase in proficiency on practically all tasks when compared to the two- and four-month retention scores. Since it was clear that these data did not reflect forgetting, we elected not to conduct any detailed analyses

of them. (The increased proficiency was attributed to a variety of procedural artifacts introduced by the participating unit [see Rose, et al., ibid.]).

Soldier abilities. We conducted an analysis to assess whether individual abilities of soldiers, as measured by the ASVAB, were related to performance. We found no systematic relationships between a single composite score or a set of composite scores and performance on a large number of tasks. Rather, for some of the tasks, all of the composite scores seemed to be correlated with performance fairly well, while for other tasks, performance was not related at all to ASVAB scores. Furthermore, we could not detect any commonalities among the tasks (and measures) that were or were not correlated with ASVAB.

Year II: The User's Decision Aid (UDA)

UDA development. During Year II, a major goal of the project was to begin development of a convenient, practical method that individual unit commanders and training managers could use when deciding how to allocate training resources based on task retention predictions. The core of this UDA would consist of a way to estimate or predict a unit's level of proficiency for any given task at any given point in time -- that is, an algorithm that generates "pure" task retention functions. The basis for such an algorithm was the TCS described above in the review of Year I research.

During Year II, we identified certain task dimensions that were most likely to be related to retention. We then converted these dimensions into rating scales, developed anchor points, and analytically assigned weights to each point on the scales. Next, we assessed each scale's reliability and validity by having several judges rate tasks on each scale. We examined both interrater agreement and the correlation between task ratings and actual retention data. These steps were repeated -- dimensions were redefined, different weights chosen, new dimensions added -- several times in order to develop a set of rating scales for the UDA.

We also worked on field implementation of the UDA -- how it should be presented to the user, how judgments should be recorded and processed, and how the resulting predictions and estimates of performance should be displayed. We developed two different versions of the UDA for possible implementation, depending upon potential resources available in the field. The first was a computer program, where users interact directly with the program via a computer keyboard. The second was a paper-and-pencil version, where users record their responses and manually compute task retention estimates.

The heart of the UDA is an algorithm that weights and summarizes the relevant characteristics of a task to produce a single task retention "score." This score is used to predict the level of task proficiency of a unit over time.

Users rate tasks by answering a series of questions posed by the UDA. Their answers are combined by the algorithm to produce both a retention score and a projected rate of proficiency loss.

UDA evaluation. A preliminary examination of the UDA algorithm revealed several important findings. First, the interrater reliability was relatively high (e.g., r = .90+). Second, the algorithm appeared to tap characteristics of tasks that are relevant to the training of military personnel. The summary retention scores and the component ratings correlated significantly with retention performance measures of accuracy and time.

The evaluation also highlighted the directions that further development should take. The algorithm needed further testing and refinement in four areas. First, terms used in the algorithm required more complete, unambiguous definitions. Second, the instrument needed to be tested with a greater number of tasks having more diverse characteristics. Third, the number and variety of raters using the algorithm needed to be increased. Finally, the algorithm needed to be examined in relation to retention over longer periods of time (e.g., 2-6 months).

Year II: Predicting Performance

Regression analyses. An important practical question for this project is whether acquisition and retention performance can be predicted from other information. During Year II, we employed two types of regression analyses to predict performance. The first type used individual difference variables (e.g., ASVAB scores) to predict soldiers' performance separately for each task. The second analysis used task difference and group difference variables to predict <u>overall</u> task performance: that is, differences <u>among</u> the entire set of tasks.

In the first set of regression analyses, we wanted to see whether measures of individual ability and frequency and recency of task performance would predict first-trial Acquisition performance. For first-trial Acquisition scores, the analyses suggested that soldiers' individual differences did not seem to predict their performance on a <u>given</u> task. In a second set of regression analyses, however, we found that information about group and task characteristics <u>could</u> be used to predict <u>group</u> Acquisition performance on a <u>set</u> of tasks.

We performed multiple regression analyses similar to those used to analyze the first-trial Acquisition data to see if individual difference variables or group and task variables could predict two-month retention performance.

For most tasks, our regression equations based on individual difference variables accounted for a larger proportion of the variance in two-month retention performance than they could account for when predicting Acquisition performance. Prediction of performance for the mental tasks was fairly good. Our individual difference variables did not predict performance very well on the physical tasks. However, task variables, especially the UDA ratings, demonstrated substantial correlations with two-month retention performance: correlations ranged between $r = 0.80$ and $r = 0.90$, depending upon the dependent measure chosen to characterize performance.

We performed regression analyses to determine whether four-month retention performance could be predicted by individual difference variables and by group and task variables. Prediction of four-month retention performance was, for the most part, not quite as good as prediction of two-month retention performance. No more than about 25% of the variance in any performance measure was accounted for by the set of individual difference predictors. However, the UDA ratings were again highly correlated with retention performance.

The primary implication of these results is that it is possible to estimate soldiers' proficiency fairly accurately over time. For certain performance measures (i.e., "Percentage of soldiers GO" and "Percentage of steps GO"), excellent estimates of proficiency could be obtained from the task ratings produced by the UDA.

II. YEAR III: ACQUISITION AND RETENTION OF CANNON CREWMAN TASKS

A major activity during Year III was the collection of acquisition and retention data for a sample of 13B10 (Cannon Crewman) MOS tasks. The goals of this activity were:

- to empirically establish the acquisition and retention functions for a variety of Cannon Crewman tasks;
- to continue exploration of the relationships of soldier abilities, level of initial learning, task characteristics, and retention interval to retention; and
- to provide criterion data for the assessment of the validity of the UDA.

Method

Selection of MOS

The MOS for Year III was 13B10, Cannon Crewman. We selected this MOS because it had begun implementing the Cohesion Operational Readiness and Training (COHORT) program. Under this program, all soldiers in a One Station Unit Training (OSUT) battery are assigned as a group to the same unit and stay in that unit throughout their first tour of duty. Our experience with an Infantry COHORT company during Year II had confirmed our expectation that the reduction in personnel turbulence in the COHORT program would enhance the feasibility of a longitudinal retention design.

Selection of Tasks

The initial domain of tasks consisted of all 13B-specific, Skill Level one (SL1) tasks listed in Soldier's Manual FM 6-13B (U.S. Army, 1982). We then narrowed the domain to tasks that were performed by the supporting battalion at Fort Ord, California. Since the battalion was assigned to the M198 (Towed) Howitzer, we excluded tasks performed on other howitzers.

We also excluded tasks that pertained to restricted duty positions, specifically Vehicle Driver, Artillery Mechanic, Assembler: 155-MM Atomic Projectile, Demolitions, and Nuclear Security. Our rationale for these exclusions was twofold: First, we anticipated serious support problems since qualified personnel and equipment necessary to test and train these tasks would not be available from the supporting unit. Second, we wanted the battalion to perceive their participation in the project as beneficial to all duty positions. Finally, we excluded tasks from the initial domain that were similar to Infantry tasks tested in Year II. We therefore did not consider Navigation, Communication, or Combat Tactics tasks.

The resulting domain for task selection consisted of the 26 tasks listed in Table 1. We gave priority to tasks that had been trained in OSUT and tested in the End of Course (EOC) test in OSUT. We wanted to select a set of tasks that would include a wide range of initial proficiency levels. Therefore, we used the percent of SL1 soldiers in the Army Occupational Survey Program (AOSP) survey who said they had performed the task as an indicator of proficiency: we expected that the tasks performed by smaller numbers of incumbents would be associated with lower initial test scores.

The final consideration was to be sure that the set of tasks selected could be tested with the resources of the supporting battalion. Those resources dictated that at least 30 soldiers had to be tested per day, using no more than one battery's equipment. We identified a set of eleven tasks that could be tested within the time and equipment constraints. Those tasks are marked "Selected" under REMARKS in Table 1.

After we had developed the initial drafts of the tests of the eleven tasks, we tried them out with the supporting battalion. The tryout and the results are discussed later under Test Development; part of the tryout, however, affected task selection. Before the tryout, four noncommissioned officers (NCOs), who were to serve as scorers, reviewed the tests. As a result of this review, the test of Perform Preventive Maintenance Checks and Services (PMCS) was deleted and replaced by the Perform Gunner's Quadrant Micrometer Test. This is by doctrine a SL3 task, but it is relevant to the M198 SL1 because the quadrant must be used to boresight.

Table 1
Summary of Review of 13B (M198) SL 1 Tasks

		TRAINED OSUT	TESTED EOC	AOSP FREQ	CANNONEER POSITION	REMARKS
COMMON MOS TASKS (SL1)						
061-266-1101	Prepare a position to receive/emplace a howitzer	YES	NO	48	(As Assigned)	Selected
061-266-1102	Record/maintain fire mission data on DA Form 4513 (Record of Missions Fired)	NO	NO	12	(As Assigned)	
061-266-1103	Emplace/recover collimator	YES	YES	70	#3 or 4	Selected
061-266-1104	Emplace/recover aiming posts	YES	YES	66	#3 or 4	Selected
AMMUNITION (SL1)						
061-266-1501	Load howitzer ammunition on vehicles	YES	NO	45	(As Assigned)	
061-266-1504	Store ammunition in preparation for firing	YES	NO	35	All	No inert ammunition in unit
CREW SERVED WEAPONS (SL1)						
071-312-3005	Perform operator maintenance on an M60 machinegun and ammunition	YES	YES	46	(As Assigned)	Selected
071-312-3007	Prepare a range card for an M60 machinegun	YES	NO	18	(As Assigned)	
071-313-3451	Perform operator maintenance on a caliber .50 HB machinegun and ammunition	NO	NO	33	(As Assigned)	Cal .50 not primary weapon of Light Inf Division

Table 1 (continued)

		TRAINED OSUT	TESTED EOC	AOSP FREQ	CANNONEER POSITION	REMARKS
071-313-3453	Load, reduce a stoppage, unload, and clear a caliber .50 machinegun	YES	NO	21	(As Assigned)	
071-313-3454	Engage targets with a caliber .50 machinegun	YES	NO	21	(As Assigned)	
071-313-3455	Set headspace and timing on a caliber .50 machinegun	YES	NO	32	(As Assigned)	
071-313-3461	Mount/dismount a caliber .50 HBM2 machinegun on a tripod	YES	NO	34	(As Assigned)	
071-313-3462	Mount/dismount a caliber .50 HBM2 machinegun on a tracked vehicle	YES	NO	34	(As Assigned)	
(M198) CANNONEER (SL1)						
061-266-1506	Prepare separate loading ammunition for firing	YES	(SP Only)	62	All	Selected
061-271-1212	Boresight the direct fire telescope using a distant aiming point (DAP)	YES	NO	35	Assistant Gunner	Selected
061-271-1215	Set/lay the cannon for quadrant with the range quadrant	YES	NO	30	Assistant Gunner	Selected
061-271-1216	Measure the quadrant with the range quadrant	YES	NO	28	Assistant Gunner	Selected
061-271-1217	Sight on a target with the direct fire telescope (M198)	YES	NO	29	Assistant Gunner	Selected

Table 1 (continued)

		TRAINED OSUT	TESTED EOC	AOSP FREQ	CANNONEER POSITION	REMARKS
061-271-1410	Disassemble/assemble breech and firing mechanism (M198)	YES	NO	28	(As Assigned)	Selected
061-271-1507	Load and fire a prepared round	YES	YES	40	All	Crew drill.
M712 AMMUNITION (SL1)						
061-266-1509	Inspect the M712 projectile	NO	NO	N/A	All	CONUS units did not have the M712 training projectile
061-266-1510	Repackage the M712 projectile	NO	NO	N/A	All	
061-266-1511	Perform extraction procedures on M712 projectile	NO	NO	N/A	All	
061-266-1512	Unpackage and prepare the M712 projectile	NO	NO	N/A	All	
(M198) CANNON MAINTENANCE (SL1)						
061-271-1601	Perform preventive maintenance checks and services (PMCS) (M198)	NO	NO	15	All	Selected

The final eleven tasks fell into three groups. The tasks selected by group were:

- Individual tasks -- perform operator maintenance on the M60 machinegun, disassemble/assemble breech mechanism, prepare a position to receive/emplace a howitzer;
- Crew tasks -- Emplace/recover aiming posts, emplace/recover collimator, prepare separate loading ammunition for firing; and
- Advanced tasks -- Measure quadrant with range quadrant, set/lay cannon for quadrant with range quadrant, sight on a target with direct fire telescope, gunner's micrometer test, and boresight direct fire telescope using Distant Aiming Point method.

Test Development

We developed a hands-on test for each selected task, following the format for SQT hands-on tests. Each test included:

- an equipment list that specified equipment required at the station,
- instructions to the scorer on how to set up the test site,
- instructions to the scorer on how to standardize test conditions,
- instructions to the scorer on how to evaluate performance not specified on the scoresheet,
- instructions for the scorer to read to soldiers to begin the test, and
- scoring points that the scorer was to mark GO or NO GO for each soldier.

The test approaches are summarized in Table 2. The complete tests for the selected tasks are in Appendix A.

Our final step in test development was to conduct a check of scoring procedures for each test. In these tryouts, four NCO (E5 or E6) scorers were given the various instructions described above, and each scorer performed each task. They then simultaneously and independently evaluated five SL1 soldiers on each task. The scorers and tested soldiers were from the supporting battalion.

The scorers administered the tests to each of the five SL1 soldiers. After each soldier finished a given test, the scorers discussed their GO/NO GO ratings. Project staff resolved the disagreements through discussion of doctrine governing the task or revision of the scoresheets. Scorers did not change the rating of the soldier they had just evaluated, but they did modify scoring of later soldiers.

Although the emphasis in these tryouts was on the qualitative evaluation of the scoring procedures, quantitative analyses were also conducted to estimate the extent to which raters could reliably judge soldier performance. Using generalizability theory (Brennan, 1983), an approach based on analysis of variance, we analyzed the results of the tryouts. This approach produces an index called a generalizability coefficient which indicates the accuracy of scoring procedures. These coefficients range from 0.00 to 1.00. The closer to 1.00, the more accurate the raters. The approach produces the index in a way which allows reasons for the raters' inconsistencies in scoring to be determined when the generalizability coefficient is low, e.g., less than 0.60.

Generalizability analyses produce estimates of why test scores vary. In this case, test scores may differ because (1) the soldiers being tested differ; (2) the raters giving the scores differ (e.g., some raters are consistently hard and others easy); or (3) the raters are inconsistent (i.e., each rater randomly shifts from being an easy rater to being a hard rater). The second and third sources of influence in the scores obviously make the scores inaccurate. The smaller those sources of variation compared to the variation among soldiers, the more accurate the scores are. Table 3 presents the results including generalizability coefficients and estimates of the influence of the two kinds of rater error on the test scores.

Table 2
Summary of Approaches for Hands-On Tests

Task	Approach
Prepare a Position to Receive/Emplace a Howitzer	The soldier acted as a gun guide. He installed the pantel and gun guide stakes, set up a field telephone, and recorded deflection from the aiming circle and meters from the aiming circle to the pantel stake. Because of differences among SOP, distance between stakes was not scored.
Emplace/Recover Collimator	A scorer's assistant operated the gunner's telescope while the tested soldier set up the collimator. Since there was a difference among the Batteries' SOP regarding the location of the collimator, scorers accepted a wider range of positions than anticipated.
Emplace/Recover Aiming Posts	The howitzer was positioned in location that allowed at least 100 meters of level terrain. The instructions gave a situation that required installation of night-lighting devices. Soldiers had to install night-lighting devices, position the near post at about 50 meters, position the far post at about 100 meters and adjust the near post following scorer's hand and arm signals. The scorer evaluated the distance by counting steps to the position (33-36).
Perform Operator Maintenance on the M60 Machinegun	The soldier had to clear the M60 (without cue), disassemble the M60, assemble the M60, and perform a function check.
Prepare Separate Loading Ammunition for Firing	Because there were no inert rounds available, soldiers selected from color drawings of rounds, fuzes, and powder. The drawings of the rounds did not include the ammunition type. The scorer gave five fire commands. For each command, the soldier recorded the command on a Record-of-Fire Form, then indicated the round (based on accurate

Table 2 (continued)

Task	Approach
	markings and approximate color), and indicated the correct fuze. For two commands the soldier set an inert fuze. For one command the soldier also indicated the powder charge required.
Boresight the Direct Fire Telescope Using a Distant Aiming Point (DAP) (M198)	This test was more complex for the M198 than it would have been for other howitzers. Because of a quirk in the M198 center vent, the soldier had to adjust the lay of the tube 2.3 mils before aligning the telescope with the gun tube. The adjustment required use of the gunner's quadrant and recall of the amount to subtract. There was a two minute time limit.
Perform Gunner's Quadrant Micrometer Test	The soldier set the micrometer to zero and the index arm to +10, put the quadrant on the quadrant seats, elevated or lowered the tube until the quadrant bubble was level, reversed the settings, and rechecked. There was a one minute time limit.
Set/Lay Cannon for Quadrant with the Range Quadrant (M198)	The scorer announced a quadrant. The soldier, acting as assistant gunner (AG), repeated the command, set the quadrant, centered the longitudinal bubble by elevating or depressing the tube, centered the cross-level bubble, and announced SET. There was a 30 second time limit.
Measure the Quadrant with the Range Quadrant (M198)	The scorer measured the quadrant of the tube then off-set the longitudinal and cross-level bubbles. The soldier, acting as AG, had to center the bubbles and announce the quadrant within 15 seconds. The command was "Measure the quadrant." After the training phase some soldiers reported that they were used to the command "Level the bubbles."

Table 2 (continued)

Task	Approach
Sight on a Target with the Direct Fire Telescope (M198)	A target was positioned at a range of about 200 meters (the limit for the test site). The scorer announced a direct fire command with the range element in meters. The soldier had to repeat the range, convert the range to mils (from a conversion plate), lay the appropriate reticle point on the target, and repeatedly announce SET. There was a 30 second time limit.
Disassemble/Assemble Breech and Firing Mechanism (M198)	The soldier disassembled the breech mechanism, assembled the breech, and performed a function check (uncued). The operator's TM was available and soldiers were scored NO-GO if they did not open the TM. For the acquisition phase, soldiers had to open to the correct section before proceeding, but they rarely referred to the TM after that.

The Mean column shows the level of performance on the complete task. It is the number of GO performance measure ratings from the four scorers for the five tested soldiers divided by the total number of performance measure ratings for the task.

The Rater Main Effect column shows the extent to which scores varied because some scorers tended to be stricter or more lenient than others. No evidence of consistent differences among scorers emerged. Therefore, the use of different scorers for different soldiers during data collection would have had no effect on the relative standing of soldiers.

The Interaction Effect column shows the extent to which any scorer was inconsistent. Compared to the estimates of person differences, the effects were negligible except for two tests -- Perform Gunner's Quadrant Micrometer Test and Sight on Target.

The last column shows the Generalizability Coefficients for each test. These indicate how accurate test scores would be if different scorers were used to score the tests. The numbers were derived by dividing person variance by the sum of person variance plus both error variance estimates.

For the most part, the generalizability coefficients shown in Table 3 are high. There were, however, two tasks with coefficients below 0.60 -- Prepare Position and Sight on Target. For Prepare Position, the raters' interaction error was nearly half the size of true-person differences. This resulted from disagreements among raters regarding unit SOP and test doctrine. We modified the scoring points to accommodate those differences. We were not able to identify the source of problems with Sight on Target. The scoring points that had disagreements were both oral responses -- "Repeated the announced range" and "Repeatedly announced SET." Scoring of both should have been reliable. The most likely explanation was that the similarity of the soldiers magnified the scorers' unfamiliarity with the doctrine. The test was retained with the expectation that greater familiarity with the task by the scorers and tested soldiers would result in acceptable reliability for this task.

Table 3
Interrater Reliability

Task	Mean	Variance			Generalizability Coefficient
		Person	Rater Main Effect	Interaction	
Prepare Position	.69	.003	.000	.002	.56
Emplace/Recover Collimator	.96	.001	.000	.000	.93
Emplace/Recover Aiming Posts	.78	.019	.000	.003	.85
Perform Operator Maintenance on M60	.93	.001	.000	.000	.99
Prepare Ammunition	.84	.018	.000	.000	.99
Boresight Direct Fire Telescope	.85	.012	.000	.002	.89
Perform Gunner's Quadrant Micrometer Test	.57	.070	.001	.036	.65
Set/Lay Cannon for Quadrant	.91	.008	.000	.003	.70
Measure Quadrant	.57	.020	.000	.007	.73
Sight on Target with Direct Fire Telescope	.15	.007	.000	.022	.25
Disassemble/Assemble Breech	.90	.001	.000	.000	1.00

Several tasks in this experiment are made up of more than one major subtask. For example, "Perform Operator Maintenance on the M60 Machinegun" has four distinct parts, with different task characteristics. To determine whether these subtasks had different acquisition and retention functions, we subdivided five of the original tasks into sixteen smaller units, each dealing with a specific procedure:

Emplace/recover collimator:

- Emplace collimator
- Recover collimator

Prepare separate loading ammunition for firing:

- Select ammunition
- Select powder
- Set fuze

Perform operator maintenance on the M60 machinegun:

- Clear
- Disassemble
- Assemble
- Function check

Disassemble/assemble breech mechanism:

- Read TM
- Disassemble
- Assemble
- Function check

Prepare a position to receive/emplace a howitzer:

- Install stakes
- Establish communication
- Record information.

The analyses were conducted on these sixteen tasks and the following six, bringing the final roster to 22 tasks:

- Measure quadrant with the range quadrant
- Set/lay cannon for quadrant with range quadrant
- Sight on a target with the direct fire telescope
- Perform gunner's quadrant micrometer test
- Boresight direct fire telescope using distant aiming point method
- Emplace/recover aiming posts.

Note that the first step of Disassemble/assemble the breech mechanism is to open the Technical Manual to the appropriate page; this was scored as a separate task. Also, note that Emplace/recover aiming posts was treated as one task, since the two components do not involve different task characteristics.

Data Collection

The experiment called for the data to be collected at four distinct periods, approximately two months apart. The first period, Acquisition, was conducted June 13-17, 1983. All soldiers were tested and trained at this time. The retention tests were conducted on August 17-18, November 16-18, and January 16-19. (These tests will be referred to as Retention 1, Retention 2, and Retention 3, respectively, throughout the remaining text.)

The original experimental design called for participation by 150 soldiers. All were to be tested and trained during Acquisition. The design called for 50 soldiers to be tested at all three retention periods, 50 more to be tested at the second and third retention periods, and 50 more to be tested at the third retention period only. Table 4 shows the configuration of soldiers actually tested at each period. Only 145 soldiers were actually tested at Acquisition.

Table 4: Soldiers Tested During Retention Testing

Subject Groups	Retention 1	Retention 2	Retention 3
Three Sessions	60	47	51
Two Sessions		43	36
One Session			27
TOTAL	60	90	114

As in any experiment of this kind, attrition occurs. Of the original 145 soldiers tested during Acquisition, 15 were lost due to illness, discharge, or transfer. Additionally, some soldiers failed to take tests for which they were scheduled. The resulting test groups were:

Tests Taken	No. of Soldiers
Retention 1, 2, 3	41
Retention 2, 3	36
Retention 3	27
Retention 1, 2	6
Retention 1, 3	10
Retention 1	3
Retention 2	7
	130

The last four groups were not part of the original design; they were included (or excluded) for each analysis as appropriate.

Scorers. Scorers for the data collection were a combination of hired civilians and NCOs from the supporting battalion. We hired seven civilians with current Field Artillery experience to augment scorers available in the unit. Six of the civilians were senior NCOs or officers in a National Guard battalion. The seventh had terminated active duty as a 13B within six months of testing. The unit provided seven NCOs (E5 and E6). One of those NCOs terminated service during the project and was hired to collect data on the remaining phases as a civilian.

The sample. The soldiers were drawn from the 13B10 MOS at Fort Ord, California. The soldiers came from three batteries and ten different sections. Forty-one (28.3%) of the soldiers listed their current duty position, at the time of Acquisition, as Cannoneer Position 1. The remaining soldiers listed various other current duty positions. Most of the sample (61%)was drawn from pay grade E2. The OSUT graduation date varied between four and twelve months prior to Acquisition.

There was nothing in the selection of soldiers for the project which would suggest that they were markedly different from the average U.S. Army entrant. The ASVAB aptitude area composite scores and the AFQT scores for 136 of the soldiers tested at Acquisition are shown in Table 5.

We compared the sample ASVAB means to a sample of 210,162 soldiers with comparable entry dates. While the comparison sample included all MOSs, we found few differences between the two groups. Our sample had lower mean scores ($p < .05$) on the Skilled Technical and Clerical tests.

Acquisition Phase Procedures

During the Acquisition phase, soldiers were tested on a series of hands-on tests covering the selected tasks. If a soldier made a mistake during the test, the scorer told him what his error was after the test was finished and had him perform the task again. If a soldier was unable to do the task at all, the scorer walked him through it. During the walk-through, the scorer told the soldier each step to perform and demonstrated steps if necessary. After the walk-through, the soldier performed the task as if he were being tested for the first time. This process was repeated until the soldier performed the task without error or assistance.

After a soldier completed this initial testing and training process for all eleven major tasks, he repeated the process two more times for about half the tasks. The clusters of tasks receiving additional repetitions are shown in Table 6. (About half the soldiers repeated Cluster A, and the rest repeated Cluster B.) In this report, we call soldiers who completed one repetition (one correct performance) on a task, "proficient." We call soldiers who completed three repetitions, "masters." Thus,

Table 5
Mean ASVAB Scores for Soldiers Participating in Acquisition Test (N = 136)

Composite	Mean	Standard Deviation
AFQT Percentile Score	47.45	17.97
Combat	100.24	13.72
Field Artillery	101.43	10.36
Electronics Repair	98.19	11.49
Operators/Food	97.41	13.53
Surveillance/Communication	98.20	12.26
Mechanical Maintenance	97.77	13.21
General Maintenance	97.64	12.84
Clerical	98.21	11.40
Skilled Technical	96.93	12.38
General Technical	100.34	13.38

Table 6
Clusters for Additional Acquisition Trials

A	B
Emplace/Recover Collimator	Prepare a Position to Receive/ Emplace a Howitzer
Emplace/Recover Aiming Posts	Perform Operator Maintenance on the M60 Machinegun
Set/Lay Cannon for Quadrant with the Range Quadrant (M198)	Prepare Separate Loading Ammunition for Firing
Measure the Quadrant with the Range Quadrant (M198)	Boresight the Direct Fire Telescope Using a Distant Aiming Point (DAP) (M198)
Sight on a Target with the Direct Fire Telescope (M198)	Perform Gunner's Quadrant Micrometer Test
Disassemble/Assemble Breech and Firing Mechanism (M198)	

all soldiers were proficient on all of the tasks and masters on about half of them.

Within a repetition, a soldier could take several trials before doing the task without error. Scorers rated the first trial (after the walk-through, if there was one) in detail. They rated steps performed correctly as GO and rated steps omitted or performed incorrectly as NO GO. They also kept track of time for each trial (not counting the walk-through) and the total number of trials (counting the walk-through, if any) for each repetition.

Retention Phase Procedures

At Retention 1 and Retention 2, soldiers performed each task once, with a minimum of feedback from the scorers. That is, scorers did not give any information about overall performance or about specific steps. Scorers rated each step GO or NO GO and recorded the time.

Retention 3 was similar to the Acquisition phase except that soldiers did only one repetition (all the trials with feedback needed to perform the task without error).

Additional Data Collected

At each phase, soldiers filled out a form which asked questions about their current position and their specific practice history for the tasks tested. During the Acquisition phase, soldiers reported how frequently they had performed a given task since OSUT and how recently they had performed it. During the Retention phases, soldiers answered the same questions but only for the time period of the retention interval. The questionnaires are shown in Appendix B.

We also interviewed the Section Chiefs of the tested soldiers after each phase. At that time, we asked them to identify each soldier's duty position and to indicate the dates for their major training events (such as the Army Readiness Training Evaluation Program, or "ARTEP"). We then checked the Job Books for the soldiers. The Job Book, if kept up to date, indicates the last time that the soldier performed the task under the Section Chief's supervision. The forms for the supervisor are shown in Appendix C.

We did an analysis, where data were available, of the self reports vs. Section Chief and Job Book data. The results of this analysis can be found in Appendix D.

Acquisition Results

To review briefly, during Acquisition testing all (145) soldiers were initially tested and scored on all 22 tasks (six primary tasks and 16 major subtasks). Task scoring consisted of a task-level GO/NO GO measure (i.e., whether or not all steps were performed correctly), step-by-step GO/NO GO measures, and (when appropriate) time for task performance. Following this initial testing, all soldiers were trained to proficiency on all tasks. That is, soldiers were given feedback on their performance, instructed on how to perform the task correctly, and retested (and rescored). Thus, we were able to collect a rough "acquisition difficulty" measure -- namely, Trials to Proficiency: how many times the soldier had to be instructed before he could perform the task correctly.

After performing all tasks correctly, each soldier repeated the test-train-retest cycle twice more for half of the tasks. This was the "Mastery" training. Performance was scored (GO/NO GO, steps GO/NO GO, and time) for each of these repetitions. The scores from the three repetitions of the Mastery group were used to reflect rate of acquisition.

First Trial Performance

Performance on the first trial of Acquisition varied markedly across tasks (see Table 7). The Advanced tasks were the most difficult. Of the five tasks within this group, three -- Boresight Telescope, Micrometer Test, and Sight Target -- were passed initially by fewer than 25% of the soldiers. Boresight Telescope was the most difficult, as assessed by both accuracy measures (percentage soldiers GO, mean steps correct) and the difficulty measure (trials to proficiency). Only 13.8% of the soldiers were able to complete this test on their own; the others were talked through the test.

Crew tasks enjoyed the highest accuracy rates. No soldier was talked through any of these tasks. Emplace and Recover the Collimator and Select Powder were each passed by over 90% of the soldiers at the first test.

Table 7
First-Trial Acquisition Performance

Tasks	Percentage of Soldiers "GO"	Percentage of Steps Correct		First Trial Time (Secs.)		Trials to First Criterion	
		Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Measure Quadrant	46.9	62.4	*47.3*	17.14	*8.90*	1.59	*.71*
Set/Lay Cannon	72.4	82.2	*35.1*	21.20	*9.31*	1.29	*.48*
Sight Target	20.7	31.7	*42.4*	16.84	*9.81*	1.98	*.62*
Micrometer Test	24.3	38.4	*46.6*	50.22	*16.99*	1.70	*.66*
Boresight Telescope	9.7	12.0	*31.3*	140.49	*42.30*	2.31	*.80*
Emplace/Recover Aiming Posts	76.6	96.4	*7.3*	79.63	*17.67*	1.21	*.42*
Emplace Collimator	94.4	99.6	*1.9*	88.61	*19.00*	1.06	*.27*
Recover Collimator	97.9	87.2	*1.8*	41.62	*8.92*	1.02	*.14*
Select Ammunition	34.5	83.1	*18.8*	Not Timed		1.69	*.57*
Select Powder	99.3	99.7	*4.2*	Not Timed		1.69	*.57*
Set Fuze	83.4	89.7	*24.9*	Not Timed		1.69	*.57*
Clear M60 Machinegun	89.6	93.1	*23.2*	Not Timed		1.06	*.24*
Disassemble M60 Machinegun	86.1	93.4	*22.0*	134.64	*41.92*	1.17	*.41*
Assemble M60 Machinegun	93.0	94.9	*21.7*	171.19	*41.75*	1.07	*.28*
Function Check M60 Machinegun	86.0	92.2	*24.2*	Not Timed		1.15	*.43*
Read TM-Breech	21.4	21.4	*0.4*	Not Timed		1.38	*.55*
Disassemble Breech	65.5	55.2	*39.6*	72.45	*44.66*	1.38	*.55*
Assemble Breech	59.7	65.2	*46.9*	123.92	*59.55*	1.41	*.52*
Function Check Breech	65.5	53.1	*37.7*	Not Timed		1.35	*.49*
Install Stakes	27.6	33.5	*45.6*	213.29	*82.36*	1.96	*.74*
Establish Communication	33.8	48.0	*47.4*	213.20	*88.33*	1.81	*.72*
Record Information	39.3	41.4	*48.4*	Not Timed		1.78	*.73*

Performance on the individual tasks varied markedly. Tasks associated with the M60 machinegun were performed correctly on the first trial by over 85% of the soldiers. Tasks associated with preparing a position (Install Stakes, Establish Communication, Record Information) were passed, on the average, by only one-third of those tested. Read TM-Breech was the only individual task passed by fewer than 25% of the soldiers.

Previous Experience

Soldiers were asked when they had last performed any of the tasks prior to the Acquisition training and testing. The results are shown in Table 8. (Please note that only self-report data were available.) Ninety percent of the participants stated they had not performed tasks associated with the M60 machinegun within the last six months. In the month preceding testing, the Prepare a Position tasks had been performed by only 16.6% of the soldiers. During this same time frame, Breech tasks had been performed by approximately 40% of the soldiers. All other tasks were reported as being performed, on the average, by a third of the sample the month before Acquisition.

The self reports were further scrutinized to investigate the reporting pattern of individual soldiers. Forty-nine of the soldiers (33.7%) stated that they had done none of the tasks within the last month. Forty-five (31.0%) stated that they had done over half of the tasks in the last month. In general, the soldiers reported doing an average of four tasks within the last month. Nearly all (97.9%) of the soldiers reported doing at least one of the tasks in the last six months. On the average, eight of the tasks were done by soldiers in the last six months.

Mastery/Proficiency Differences

Tables 9-11 show accuracy measures and time broken down by Mastery/Proficiency groups and by the three repetitions of the Mastery group. We looked for differences between the Mastery and Proficiency groups at the first trial of Acquisition. We found few statistically significant differences between the groups; these differences occurred at the rate that we might have expected if left to chance. Referring to Table 9, only one task -- Set/Lay Cannon -- showed significant differences between groups on first-trial performance (corrected $Z = -1.80$, $p < 0.05$). Soldiers in the proficiency group

Table 8
Recency Estimates for Task Performance Prior to Acquisition Test (Self Reports)

Tasks	% Soldiers Reporting Task Performance within Last Month	% Soldiers Reporting Task Performance Between 1 and 6 Months Ago	% Soldiers Reporting No Task Performance in Last 6 Months
Measure Quadrant	37.9	34.5	27.6
Set/Lay Cannon	30.3	31.7	37.9
Sight Target	31.7	35.9	32.4
Micrometer Test	37.2	29.0	33.8
Boresight Telescope	30.3	30.3	39.3
Emplace/Recover Aiming Posts	30.3	56.6	13.1
Emplace Collimator	34.5	52.4	13.1
Recover Collimator	34.5	52.4	13.1
Select Ammunition	35.9	45.5	18.6
Select Powder	35.9	45.5	18.6
Set Fuze	35.9	45.5	18.6
Clear M60 Machinegun	5.0	4.3	90.7
Disassemble M60 Machinegun	5.0	4.3	90.7
Assemble M60 Machinegun	5.0	4.3	90.7
Function Check M60 Machinegun	5.0	4.3	90.7
Read TM-Breech	40.7	37.9	21.4
Disassemble Breech	40.7	37.9	21.4
Assemble Breech	39.3	37.2	23.5
Function Check Breech	39.3	37.2	23.5
Install Stakes	16.6	30.3	53.1
Establish Communication	16.6	30.3	53.1
Record Information	16.6	30.3	53.1

Table 9
Percentage of Soldiers "GO" on Acquisition Tests by Training Condition

	1st Trial				2nd Trial	3rd Trial
	Proficiency		Mastery			
	N	%	N	%	%	%
TASKS						
Measure Quadrant	72	47.2	73	46.6	89.0	95.8
Set/Lay Cannon	72	79.2*	73	65.8	97.3	98.6
Sight Target	72	25.0	73	16.4	89.0	94.3
Micrometer Test	72	25.0	72	23.6	94.4	98.6
Boresight Telescope	71	9.9	73	9.6	91.7	98.6
Emplace/Recover Aiming Posts	72	80.6	69	72.5	98.6	100.0
Emplace Collimator	71	95.8	73	93.2	98.6	98.5
Recover Collimator	71	98.6	73	97.3	100.0	98.5
Select Ammunition	70	34.3	75	34.7	93.1	97.2
Select Powder	70	81.4	75	85.3	100.0	100.0
Set Fuze	70	98.6	75	100.0	98.6	100.0
Clear M60 Machinegun	72	90.3	72	88.9	100.0	100.0
Disassemble M60 Machinegun	72	87.5	72	84.7	98.6	100.0
Assemble M60 Machinegun	73	91.8	70	94.3	100.0	100.0
Function Check M60 Machinegun	73	87.7	70	84.3	100.0	100.0
Read TM-Breech	72	23.6	73	19.2	95.9	100.0
Disassemble Breech	72	66.7	73	64.4	94.3	100.0
Assemble Breech	71	63.4	73	56.2	98.6	100.0
Function Check Breech	72	66.7	73	64.4	98.6	98.6
Install Stakes	78	26.9	67	28.4	91.0	95.5
Establish Communication	78	37.2	67	29.9	95.5	97.0
Record Information	78	42.3	67	35.8	97.0	100.0

* Difference in proportion significant at the .05 level.

Table 10
Mean Percentage of Steps Correct on Acquisition Tests by Training Condition

TASKS	1st Trial				2nd Trial	3rd Trial
	Proficiency		Mastery			
	N	Mean	N	Mean	Mean	Mean
Measure Quadrant	72	64.0	73	61.0	99.3	100.0
Set/Lay Cannon	72	84.7	73	79.7	99.7	100.0
Sight Target	72	33.8	73	29.7	97.7	97.6
Micrometer Test	72	39.4	72	37.5	97.9	100.0
Boresight Telescope	71	14.1	73	9.9	99.0	100.0
Emplace/Recover Aiming Posts	72	97.1	69	95.7	99.8	100.0
Emplace Collimator	71	99.7	73	99.4	99.9	99.9
Recover Collimator	71	99.7	73	99.8	100.0	99.9
Select Ammunition	70	84.0	75	82.4	99.0	99.6
Select Powder	70	99.3	75	100.0	100.0	100.0
Set Fuze	70	90.0	75	89.3	99.3	100.0
Clear M60 Machinegun	72	93.8	72	92.4	100.0	100.0
Disassemble M60 Machinegun	72	94.0	72	92.8	99.8	100.0
Assemble M60 Machinegun	73	95.5	70	94.3	100.0	100.0
Function Check M60 Machinegun	73	92.9	70	91.4	100.0	100.0
Read TM-Breech	72	23.6	73	19.2	95.9	100.0
Disassemble Breech	72	68.1	73	64.4	98.3	100.0
Assemble Breech	72	67.1	73	63.4	74.8	100.0
Function Check Breech	72	67.4	73	64.4	99.3	99.3
Install Stakes	78	34.0	67	32.8	97.4	98.9
Establish Communication	78	51.0	67	44.4	99.5	99.7
Record Information	78	44.2	67	38.1	98.5	100.0

Table 11
Mean Time to Perform Tasks on Acquisition Trials by Training Condition

Tasks	Proficiency			Mastery			
	N	1st Trial Mean	Final Trial Mean	N	1st Trial Mean	2nd Trial Mean	3rd Trial Mean
Measure Quadrant	72	17.3	13.2	73	17.0	14.3	13.2
Set/Lay Cannon	69	21.3	19.8	73	21.1	16.8	16.9
Sight Target	70	15.5	10.9	73	18.1	11.4	8.9
Micrometer Test	71	51.0	44.5	72	49.5	41.4	38.4
Boresight Telescope	69	139.6	130.6	73	141.4	128.7	109.3
Emplace/Recover Aiming Posts	72	78.4	79.4	69	80.9	74.8	69.9
Emplace Collimator	71	89.1	88.0	73	88.1	75.0	71.7
Recover Collimator	69	42.4	42.4	73	40.9	37.0	36.9
Select Ammunition	Not Timed						
Select Powder	Not Timed						
Set Fuze	Not Timed						
Clear M60 Machinegun	Not Timed						
Disassemble M60 Machinegun	72	130.1	131.2	72	139.2	120.8	115.1
Assemble M60 Machinegun	73	171.3	168.3	70	171.0	159.4	153.7
Function Check M60 Machinegun							
Read TM-Breech	Not Timed						
Disassemble Breech	72	71.0	70.9	73	73.9	55.0	46.2
Assemble Breech	70	113.5*	112.5	73	133.9	103.9	92.3
Function Check Breech	Not Timed						
Install Stakes	75	216.8	208.3	67	209.3	167.8	142.2
Estabiish Communication	74	232.0	226.5	67	230.3	171.1	153.0
Record Information	Not Timed						

* Difference of means significant at .05 level.

performed the proficiency group scored "GO" on this test. No differences were found between groups on mean percentage of steps correct (Table 10). For the time variable (Table 11), Assemble Breech was the only task which showed a statistically significant difference between groups ($t = -2.07$, $p < 0.05$), the proficient soldiers performing the task faster. These initial differences between Proficiency and Mastery groups were controlled for in subsequent analyses.

Rate of Acquisition

The learning rates are indicated in several ways. A first indicator is the number of trials required to successfully reach proficiency. Table 7 shows these means. This indicator parallels the level of difficulty indicated by the percent soldiers "GO," with Boresight Telescope having the highest mean number of trials, and Recover Collimator the least. Boresight Telescope was the only task for which the mean exceeded two trials. Second, the learning rate can be indicated by the performance across trials of the Mastery group. The two accuracy measures, shown in Tables 9 and 10, indicate that soldiers learned the tasks quickly. Even the most difficult tasks at the first trial of Acquisition -- Boresight Telescope, Micr meter Test, Sight Target, and Read TM-Breech -- were passed by at least 89% of the Mastery soldiers the second time around. Eleven of the tasks were passed by 100% of the soldiers by the third trial; fifteen of the tasks had all steps passed by all soldiers in this third trial, time being the "NO GO" determinant for four of these 15.

Time provides a third indicator. Table 11 shows the average time required to perform the timed tasks. Virtually every succeeding trial showed a decrease in the amount of time the soldier required to complete the task. The differences between the first and second trials were the most dramatic. On the average the time decreased by 18% between the two trials. Time was reduced by an average of 9% across all tasks between the second and third trials. Acquisition is also reflected by the improvements in time between the first trial (before training) and last trial (after training) for the Proficiency group.

Summary of Acquisition Performance

The accuracy scores for the first trial of acquisition show that the soldiers included in the experiment had differing levels of proficiency on the selected tasks. The soldiers themselves reported a wide range of experience on the tasks in the six months prior to the test. Performance on all tasks improved substantially with training: accuracy approached 100% for the Mastery group by the third repetition. Performance time continued to decrease during the third repetition. These findings parallel our experience with the 11B tasks examined during Year II.

As a consequence of the training provided during Acquisition, performance time baselines were established against which to monitor proficiency levels during Retention testing. For the proficiency group these baselines were the soldiers' times on their final (correct) Acquisition test trial. For the Mastery group the baseline was the time on their third correct trial.

Retention Results

The retention tests were given two, five, and seven months after the Acquisition phase. Of central interest is the effect of these time intervals on performance levels. Also of interest are differences in retention performance attributable to training effects -- the Proficiency vs. Mastery regimens. We will first present the descriptive results from each testing session and introduce the variables apparently influencing performance. This discussion will be followed by a more detailed presentation of analyses aimed at predicting performance across retention intervals (see Chapter IV).

Retention Performance: Accuracy

As a global overview, we will first present performance summaries for all soldiers tested at each retention point. These summaries combine soldiers from different subgroups (e.g., Mastery and Proficiency groups, soldiers previously tested at Retention 1 or 2 and those not previously tested, etc.); breakouts of these subgroups will be presented where appropriate.

Retention performance for the accuracy measures is shown in Tables 12 (Percentage of Soldiers "GO") and 13 (Percentage of Steps "GO") for all soldiers tested. It is

Table 12
Retention Performance All Soldiers: Percentage of Soldiers "GO"

Tasks	Retention 1 (n = 60)	Retention 2 (n = 90)	Retention 3 (n = 114)
Measure Quadrant	46.7	61.1	72.8
Set/Lay Cannon	58.3	50.0	69.3
Sight Target	35.0	17.8	36.0
Micrometer Test	31.7	44.4	70.8
Boresight Telescope	19.0	20.2	45.6
Emplace/Recover Aiming Posts	70.0	52.2	96.5
Emplace Collimator	95.0	48.9	93.0
Recover Collimator	96.7	56.7	91.2
Select Ammunition	63.3	9.1	29.8
Select Powder	100.0	100.0	99.1
Set Fuze	100.0	65.1	*
Clear M60 Machinegun	90.0	85.6	99.1
Disassemble M60 Machinegun	80.0	44.9	92.0
Assemble M60 Machinegun	83.3	82.2	87.7
Function Check M60 Machinegun	98.3	95.6	100.0
Read TM-Breech	88.3	72.2	78.1
Disassemble Breech	90.0	92.2	95.6
Assemble Breech	93.3	70.0	84.2
Function Check Breech	95.0	71.1	79.8
Install Stakes	76.7	61.1	86.0
Establish Communication	76.7	62.2	84.2
Record Information	52.6	57.8	57.0

* Fuze not available during testing.

Table 13
Retention Performance All Soldiers: Percentage of Steps "GO"

Tasks	Retention 1 (n = 60) Mean	Retention 1 (n = 60) Standard Deviation	Retention 2 (n = 90) Mean	Retention 2 (n = 90) Standard Deviation	Retention 3 (n = 114) Mean	Retention 3 (n = 114) Standa Deviati
Measure Quadrant	70.3	*41.6*	76.7	*41.2*	63.3	*31.7*
Set/Lay Cannon	90.8	*17.1*	86.7	*16.1*	90.5	*17.1*
Sight Target	72.3	*29.8*	62.2	*27.0*	65.5	*31.3*
Micrometer Test	73.8	*35.0*	80.1	*32.1*	91.8	*17.8*
Boresight Telescope	43.8	*41.4*	52.4	*37.8*	75.5	*34.6*
Emplace/Recover Aiming Posts	96.4	*7.1*	87.1	*14.9*	88.0	*4.2*
Emplace Collimator	99.7	*1.4*	95.3	*6.5*	99.5	*2.1*
Recover Collimator	99.8	*1.8*	94.4	*7.0*	98.7	*4.1*
Select Ammunition	90.0	*17.3*	68.6	*21.0*	87.1	*11.7*
Select Powder	100.0	*0.0*	100.0	*0.0*	*99.6*	*4.7*
Set Fuze	100.0	*0.0*	79.5	*30.3*	*	*
Clear M60 Machinegun	96.3	*12.9*	87.8	*30.7*	99.8	*2.4*
Disassemble M60 Machinegun	96.1	*7.7*	88.0	*16.3*	98.1	*7.3*
Assemble M60 Machinegun	99.0	*3.6*	97.8	*9.3*	99.0	*3.7*
Function Check M60 Machinegun	99.7	*2.6*	96.4	*18.1*	100.0	*0.0*
Read TM-Breech	88.3	*32.4*	72.2	*45.0*	78.1	*41.6*
Disassemble Breech	95.3	*17.4*	97.1	*12.9*	98.4	*10.0*
Assemble Breech	98.5	*6.9*	94.4	*12.2*	96.2	*9.3*
Function Check Breech	96.7	*15.6*	81.7	*31.3*	89.5	*21 5*
Install Stakes	94.2	*10.7*	88.9	*15.0*	94.1	*18.3*
Establish Communication	96.5	*6.9*	94.2	*9.3*	96.8	*10.6*
Record Information	72.8	*31.4*	75.0	*32.0*	74.6	*32.1*

* Fuze not available for testing

evident from these tables that practically all tasks showed forgetting after two months: since (by design) all soldiers performed all tasks correctly on their last Acquisition test, any accuracy score less than 100% is an indication of retention loss. The task groups -- Advanced, Crew, and Individual -- maintained their relative positions regarding level of difficulty throughout the three Retention tests. That is, at each Retention test, the Advanced tasks were the most difficult, followed by Crew tasks, then Individual tasks. The Advanced tasks, characterized as the most difficult at Acquisition, showed the lowest retention. Individual tasks showed the highest rates of retention. On the average, 84% of the soldiers passed these tasks at the end of the first Retention interval.

At Retention 2, all but one of the tasks showed forgetting since Acquisition. The most dramatic drop was in Select Ammunition; only 9.1% of the soldiers passed this test, although 68.6% of the steps were performed correctly. Emplace Collimator, Set Fuze, and Disassemble M60 Machinegun each showed retention losses of over 35% from the first to the second retention testing. Select Powder continued to be passed by all soldiers tested.

The performance of soldiers at Retention 3 is more difficult to explain. On virtually every task soldiers performed better or as well at this testing than at the previous one. Comparing performance across tests, we find that at both Retention 1 and 3 fourteen of the 22 tasks were passed by 75% or more of the soldiers. At Retention 2, however, only five of the tasks fell into this category. All tasks were passed by at least 25% of the soldiers at Retention 3. At Retention 2, three tasks -- Select Ammunition, Sight Target, and Boresight Telescope -- were passed by less than 25%.

There are several potential confounding factors, including testing and practice effects, which serve to explain the Retention 3 results. This topic is taken up in more detail in Chapter IV.

Retention Performance: Time

Table 14 presents Retention results for task performance time, collapsed across all soldiers at each retention test. These data are included for the sake of completeness; however, they should be viewed cautiously.

Table 14
Retention Performance for Timed Tasks All Soldiers: Performance Time (Seconds)

TASKS	Retention 1		Retention 2		Retention 3	
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Measure Quadrant	17.8	13.1	15.5	10.6	14.5	6.2
Set/Lay Cannon	24.0	11.1	18.7	7.2	23.3	8.7
Sight Target	16.5	11.4	16.2	8.6	14.5	7.5
Micrometer Test	83.4	53.6	80.3	47.6	51.1	16.0
Boresight Telescope	147.7	61.7	120.7	54.6	118.1	38.9
Emplace/Recover Aiming Posts	80.4	14.9	74.5	12.3	78.2	13.0
Emplace Collimator	84.4	12.6	95.2	23.1	93.0	19.9
Recover Collimator	37.9	6.1	43.4	13.5	44.7	9.7
Disassemble M60 Machinegun	151.3	39.7	176.9	50.4	149.9	41.0
Assemble M60 Machinegun	198.7	58.1	198.5	44.1	175.3	43.6
Disassemble Breech	97.0	54.8	104.5	68.3	87.4	43.1
Assemble Breech	150.3	107.5	151.6	95.9	130.1	74.5
Install Stakes	111.6	34.7	112.9	41.6	106.3	36.4
Establish Communication	140.8	32.6	148.4	41.6	151.6	40.7

For example, times for task performance at Retention 2 include soldiers tested at Retention 1; therefore, direct comparisons between these means would be potentially misleading.

To more accurately describe changes in speed of performance between Acquisition and Retention performance, we compared the means between the last Acquisition trial time (regardless of training condition) and the first trial at each Retention session. The results are shown in Table 15. Thus, for example, the means listed under "Retention 2" are those of just the soldiers whose first retention test was at Retention 2. Calculating these means enabled us to statistically test for significant differences between Acquisition and Retention performance.

For the majority of tasks, more time was required for task performance during Retention tests than at the end of Acquisition. In other words, the ability to perform the tasks diminished during the retention intervals. Two major exceptions are apparent. Regardless of the time of a soldier's first retention test, the times required to Install Stakes and Establish Communication were significantly reduced compared to the last Acquisition trial. This time decrease was not what would have been expected if the major effect of the retention interval was to slow performance.

Three tasks -- Sight Target, Disassemble Breech, and Assemble Breech -- show relatively large (greater than 50%) and consistent increases in performance time between Acquisition and Retention for all retention sessions. At Retention 1, six of the tasks for which significant differences were found showed increases in performance time of less than 25%. Somewhat surprisingly, more tasks (n=10) showed increases in performance time at Retention 1 than at either Retention 2 (n=7) or Retention 3 (n=8). Furthermore, Retention 1 increases tended to be larger.

We also analyzed performance times at Retention 2 and 3, comparing soldiers previously tested with those who were taking their first retention test. At Retention 2, no significant differences were found between the two groups on any task. At Retention 3, significant differences were found between groups only on Install Stakes and Set/Lay Cannon. In each instance, the untested group took more time to complete the task than those in the group which had been previously tested.

Table 15
First Retention Performances Compared to Last Trial Acquisition: Mean Time (Seconds)

	Retention 1 (N=60)[a]		Retention 2 (N=43)[a]		Retention 3 (N=27)[a]	
TASKS	Mean Acquisition	Mean Retention 1	Mean Acquisition	Mean Retention 2	Mean Acquisition	Mean Retention 3
Measure Quadrant	13.0*	17.8	13.3	16.3	13.2	13.7
Set/Lay Cannon	18.2*	23.6	18.7	18.9	18.7	21.1
Sight Target	9.7*	15.6	10.0*	16.2	10.3*	16.5
Micrometer Test	40.4*	82.8	44.5*	83.5	41.2*	54.3
Boresight Telescope	118.5*	148.4	124.7	118.0	116.1	113.0
Emplace/Recover Aiming Posts	72.4*	80.C	75.0	73.2	80.0	80.9
Emplace Collimator	81.0	84.6	79.2*	94.1	78.7*	87.4
Recover Collimator	39.5	38.0	41.4	46.2	37.2*	42.8
Disassemble M60 Machinegun	122.5*	151.3	123.4*	184.6	122.2*	149.3
Assemble M60 Machinegun	161.4*	198.0	161.5*	200.0	157.2*	182.8
Disassemble Breech	54.6*	97.4	63.4*	108.1	58.9*	94.6
Assemble Breech	102.1*	150.6	94.4*	150.6	107.0*	160.7
Install Stakes	180.5*	109.7	164.2*	114.8	182.8*	130.2
Establish Communication	198.4*	140.1	172.2	153.4	194.0*	156.7

* Difference between means significant at .05 level, using 2-tailed t-tests.

[a] These N's are approximate and vary among tasks due to missing data for the last trial Acquisiton times.

Table 16
Retention Performance all Soldiers: Percentage of Soldiers "GO" by Training Condition

TASKS		Retention 1 (N=60) %	Retention 1 (N=60) Standard Deviation	Retention 2 (N=90) %	Retention 2 (N=90) Standard Deviation	Retention 3 (N=114) %	Retention 3 (N=114) Standard Deviation
Measure Quadrant	P	42.3	50.4	68.2	47.1	74.5	44.0
	M	50.0	50.8	54.3	50.4	71.2	45.7
Set/Lay Cannon	P	46.2*	50.8	56.8	50.1	72.7	44.9
	M	67.7	47.5	43.5	50.1	66.1	47.7
Sight Target	P	30.8*	47.1	20.5	40.8	41.8	49.8
	M	38.2	49.3	15.2	36.3	30.5	46.4
Micrometer Test	P	27.3	45.2	36.2	48.6	76.3	42.9
	M	37.0	49.2	53.5	50.5	64.8	48.2
Boresight Telescope	P	22.6	42.5	20.0	40.5	42.4	49.8
	M	14.8	36.2	20.5	40.8	49.1	50.5
Emplace/Recover Aiming Posts	M	80.8	40.2	47.7	50.5	96.4	18.9
	P	67.8	47.5	59.1	49.7	96.5	18.6
Emplace Collimator	P	96.2	19.6	51.2	50.6	90.7	29.3
	M	94.1	23.9	45.7	50.4	94.9	22.2
Recover Collimator	P	100.0	0	55.8	50.2	90.7	29.3
	M	94.1	23.9	56.5	50.1	91.5	28.1
Select Ammunition	P	64.5	48.6	9.5	29.7	23.2	42.6
	M	62.1	49.4	8.7	28.5	36.2	48.5
Select Powder	P	100.0	0	100.0	0	100.0	0
	M	100.0	0	100.0	0	98.3	13.1
Set Fuze	P	100.0	0	61.0	49.4	**	
	M	100.0	0	69.0	46.8	**	
Clear M60 Machinegun	P	85.3	35.9	86.7	34.4	98.3	13.1
	M	96.2	19.6	84.1	37.0	100.0	0
Disassemble M60 Machinegun	P	76.5	43.1	43.2	50.1	93.1	25.6
	M	84.6	36.8	45.5	50.4	92.6	26.4

Table 16 (continued)

TASKS		Retention 1 (N=60) %	Retention 1 (N=60) Standard Deviation	Retention 2 (N=90) %	Retention 2 (N=90) Standard Deviation	Retention 3 (N=114) %	Retention 3 (N=114) Standard Deviation
Assemble M60 Machinegun	P	73.5*	44.8	84.8	36.3	86.4	34.5
	M	96.2	19.6	81.0	39.7	90.6	29.5
Function Check M60 Machinegun	P	97.1	17.1	93.5	25.0	100.0	0
	M	100.0	0	97.6	15.4	100.0	0
Read TM-Breech	P	80.8	40.2	77.3	42.4	78.2	41.7
	M	94.1	23.9	67.4	47.4	78.0	41.8
Diassemble Breech	P	88.5	32.6	93.2	25.5	94.5	22.9
	M	91.2	28.8	91.3	28.5	96.6	18.3
Assemble Breech	P	96.2	19.6	79.5*	40.8	83.6	37.3
	M	91.8	28.8	60.9	49.3	84.7	36.1
Function Check Breech	P	92.3	27.2	63.6	48.7	78.2	41.7
	M	97.1	17.1	78.3	41.7	81.4	39.3
Install Stakes	P	80.0	40.6	55.1	50.3	83.6	37.3
	M	72.0	45.8	68.3	47.1	88.7	32.0
Establish Communication	P	74.3	44.3	63.3	48.7	80.3	40.1
	M	80.0	40.8	61.0	49.4	38.7	32.0
Record Information	P	31.3*	47.1	55.1	50.3	42.6*	49.9
	M	80.0	40.8	61.0	49.4	73.6	44.5

* Difference between proportions significant at .05 level.

** Fuze not available for testing.

Note: P=Proficiency; M=Mastery

Table 17
Retention Performance all Soldiers: Mean Percentage of Steps Correct by Training Condition

TASKS		Retention 1 (N=60) %	Retention 1 (N=60) Standard Deviation	Retention 2 (N=90) %	Retention 2 (N=90) Standard Deviation	Retention 3 (N=114) %	Retention 3 (N=114) Standard Deviation
Measure Quadrant	P	66.0	45.0	78.4	39.5	83.6	30.5
	M	73.5	39.4	75.0	43.1	83.1	33.0
Set/Lay Cannon	P	91.2	18.3	88.2	15.1	90.9	17.1
	M	90.6	16.5	85.2	17.1	90.2	17.2
Sight Target	P	74.7	30.9	59.1	29.5	69.7	30.9
	M	70.6	29.3	65.2	24.3	61.6	31.4
Micrometer Test	P	74.6	37.7	76.6	34.2	92.8	18.4
	M	72.7	32.0	84.0	29.5	90.7	17.2
Boresight Telescope	P	44.0	44.1	49.7	39.4	76.5	33.2
	M	43.5	38.8	55.1	36.3	74.5	36.2
Emplace/Recover Aiming Posts	M	97.5	6.3	86.4	14.7	88.4	5.3
	P	95.7	7.7	88.4	15.3	87.7	2.9
Emplace Collimator	P	99.8	1.2	95.5	6.6	99.4	2.2
	M	99.6	1.2	95.0	6.5	99.6	2.0
Recover Collimator	P	100.0	0	94.3	7.1	98.7	4.2
	M	99.6	2.5	94.4	7.0	98.8	4.0
Select Ammunition	P	90.0	18.8	66.4	22.5	85.2	12.6
	M	90.0	15.8	70.7	19.6	89.0	10.5
Select Powder	P	100.0	0	100.0	0	100.0	0
	M	100.0	0	100.0	0	99.1	6.6
Set Fuze	P	100.0	0	76.8	31.8	**	
	M	100.0	0	82.1	28.8	**	
Clear M60 Machinegun	P	94.1	16.4	88.3	30.4	99.6	3.3
	M	99.0	4.9	86.9	31.7	100.0	0
Disassemble M60 Machinegun	P	95.1	8.7	86.0	19.9	98.6	6.5
	M	97.4	6.1	89.8	11.5	97.8	8.0

Table 17 (continued)

TASKS		Retention 1 (N=60) %	Retention 1 (N=60) Standard Deviation	Retention 2 (N=90) %	Retention 2 (N=90) Standard Deviation	Retention 3 (N=114) %	Retention 3 (N=114) Standard Deviation
Assemble M60 Machinegun	P	98.3	4.7	98.3	12.2	98.5	4.4
	M	100.0	0	100.0	4.7	99.5	2.7
Function Check M60 Machinegun	P	99.4	3.4	95.2	20.7	100.0	0
	M	100.0	0	97.6	15.4	100.0	0
Read TM-Breech	P	80.8	40.2	77.3	42.4	78.2	41.8
	M	94.1	23.9	67.4	47.4	78.0	41.8
Diassemble Breech	P	94.6	20.0	98.6	5.1	97.4	13.9
	M	95.9	15.4	95.7	17.3	99.3	3.7
Assemble Breech	P	100.0	0	97.2*	7.1	95.7	10.3
	M	97.4	9.1	91.8	15.2	96.6	8.3
Function Check Breech	P	94.2	21.6	76.1	34.9	89.1	20.8
	M	98.5	8.6	86.9	26.7	89.8	22.3
Install Stakes	P	95.0	10.1	86.7	16.2	91.8	23.1
	M	93.0	11.5	91.4	13.2	96.7	9.8
Establish Communication	P	96.2	7.1	94.8	7.9	95.8	13.6
	M	96.9	6.8	93.5	10.8	97.9	5.3
Record Information	P	59.4*	32.2	70.4	36.7	65.5*	33.6
	M	90.0	20.4	80.5	24.7	84.9	27.0

* Difference between proportions significant at .05 level.

** Fuze not available for testing.

Note: P=Proficiency; M=Mastery

Table 18
Retention Performance for Timed Tasks All Soldiers: Performance Time (Seconds) by Training Condition

Tasks		Retention 1 (n = 60) Mean	Retention 1 (n = 60) Standard Deviation	Retention 2 (n = 90) Mean	Retention 2 (n = 90) Standard Deviation	Retention 3 (n = 114) Mean	Retention 3 (n = 114) Standard Deviation
Measure Quadrant	P	18.1	*13.2*	14.9	*7.9*	14.0	*6.5*
	M	17.5	*13.2*	16.1	*13.0*	15.0	*6.0*
Set/Lay Cannon	P	27.6*	*13.3*	18.6	*8.0*	22.8	*6.5*
	M	21.4	*8.4*	18.9	*6.4*	23.7	*10.5*
Sight Target	P	19.3*	*13.6*	15.8	*7.5*	14.9	*7.6*
	M	14.4	*9.0*	16.6	*9.6*	14.0	*7.4*
Micrometer Test	P	89.8	*59.7*	86.9*	*50.2*	50.4	*15.5*
	M	75.8	*45.3*	73.0	*44.0*	51.7	*16.5*
Boresight Telescope	P	154.3	*63.7*	129.5	*57.4*	120.5	*39.5*
	M	139.5	*59.5*	111.7	*50.4*	116.7	*38.6*
Emplace/Recover Aiming Posts	P	81.1	*15.8*	72.6	*11.8*	78.7	*13.8*
	M	79.7	*14.6*	76.4	*12.2*	77.8	*12.4*
Emplace Collimator	P	85.1	*13.2*	96.9	*22.7*	95.2	*22.6*
	M	83.9	*12.4*	93.5	*23.8*	90.8	*17.1*
Recover Collimator	P	36.6	*5.6*	41.6	*9.7*	44.9	*11.6*
	M	38.9	*6.5*	45.2	*16.3*	44.4	*7.6*
Disassemble M60 Machinegun	P	159.3*	*43.1*	184.6	*54.9*	149.4	*41.8*
	M	140.8	*32.8*	169.8	*45.0*	149.9	*40.9*
Assemble M60 Machinegun	P	205.6*	*63.8*	200.8	*49.7*	177.9	*42.2*
	M	189.5	*49.4*	195.6	*38.2*	169.5	*43.3*
Disassemble Breech	P	97.9	*42.6*	101.8	*58.0*	92.6	*49.4*
	M	96.4	*63.1*	107.8	*77.6*	82.7	*36.3*
Assemble Breech	P	166.1	*126.4*	129.1*	*91.3*	127.7	*72.0*
	M	138.4	*91.0*	171.7	*96.4*	132.4	*77.3*
Install Stakes	P	112.9	*35.3*	109.5	*44.0*	106.8	*36.7*
	M	109.8	*34.4*	116.9	*38.8*	105.7	*36.3*
Establish Communication	P	141.9	*32.3*	148.8	*39.0*	158.7*	*39.9*
	M	139.1	*33.8*	148.0	*45.1*	143.8	*40.5*

* Difference between means significant at .05 level.

P = Proficiency; M = Mastery

Table 19
Recency Estimates for Task Performance Prior to Retention Tests

Tasks	Retention 1 (n = 60)		Retention 2 (n = 90)		Retention 3 (n = 114)	
	% Soldiers Reporting Individual Training Since Last Test	% Soldiers Reporting ARTEP or Live Fire Since Last Test	% Soldiers Reporting Individual Training Since Last Test	% Soldiers Reporting ARTEP or Live Fire Since Last Test	% Soldiers Reporting Individual Training Since Last Test	% Soldiers Reporting ARTEP or Live Fire Since Last Test
Measure Quadrant	60.0	25.0	73.5	28.7	48.3	9.8
Set/Lay Cannon	55.0	21.6	71.1	29.5	47.4	8.1
Sight Target	53.3	5.0	65.1	29.5	48.6	8.1
Micrometer Test	46.7	20.0	63.5	24.1	29.8	7.1
Boresight Telescope	55.0	11.7	66.7	11.4	46.7	6.3
Emplace/Recover Aiming Posts	58.3	28.4	72.3	26.7	50.9	10.2
Emplace Collimator	55.0	26.6	81.9	33.0	49.1	10.1
Recover Collimator	55.0	26.6	81.9	33.0	49.1	10.1
Select Ammunition	66.6	46.7	72.2	28.4	51.4	11.7
Select Powder	66.6	46.7	72.2	28.4	51.4	11.7
Set Fuze	66.6	46.7	72.2	28.4	51.4	11.7
Clear M60 Machinegun	53.3	15.0	80.9	22.5	49.1	7.9
Disassemble M60 Machinegun	53.3	15.0	80.9	22.5	49.1	7.9
Assemble M60 Machinegun	53.3	15.0	80.9	22.5	49.1	7.9
Function Check M60 Machinegun	53.3	15.0	80.9	22.5	49.1	7.9
Read TM-Breech	53.3	20.0	76.5	30.7	51.3	10.8
Disassemble Breech	53.3	20.0	76.5	30.7	51.3	10.8
Assemble Breech	28.3	20.0	44.8	30.7	34.2	10.8
Function Check Breech	28.3	20.0	44.8	30.7	34.2	10.8
Install Stakes	35.0	16.7	59.3	23.9	28.9	9.8
Establish Communication	35.0	16.7	59.3	23.9	28.9	9.8
Record Information	35.0	16.7	59.3	23.9	28.9	9.8

In the interval between Acquisition and Retention 1, approximately 50% of the soldiers reported receiving individual training on all tasks. This percentage rose to approximately 70% between Retention 1 and Retention 2, and fell to approximately 455 between Retention 2 and Retention 3. Soldiers also reported practice on ARTEP or live-fire exercises between retention test points although the percentages were lower than for individual training. The consistency across tasks would be expected for soldiers from COHORT units.

The relatively similar amounts of intervening practice across tasks preclude any straightforward analysis of effect of practice on retention performance. Furthermore, practice may interact with several other variables (e.g., training condition). We postpone discussion of these more complex effects until Chapter IV.

Soldier Abilities

We conducted analyses to assess whether individual abilities of soldiers, as measured by the ASVAB, were related to performance. First, we computed correlations between each of the ASVAB scores and each of the performance measures for all tasks at each test phase. As was the case in Year II, although there were many significant correlations, no particular patterns emerged. Thus, we decided to explore in detail only one of the ASVAB scores, namely the Field Artillery (FA) composite.

The correlations between FA scores and accuracy and time performance data are presented in Tables 20 through 22. The correlations found at this bivariate level of analysis do not suggest that FA scores are strongly related to performance accuracy. However, as shown in Table 22, there does appear to be a relationship between FA and task performance time, especially at Retention 1. Performance on six of the fourteen timed tasks is significantly related to FA, while the correlations for four other tasks approach significance. There also are several significant correlations between FA and performance time at Retention 2 and Retention 3. As we have posited previously, performance at these latter two tests may have been affected by several (possibly interacting) variables; before we would conclude that FA is unrelated to performance over extended periods of time, we should examine results from more powerful statistical techniques capable of unravelling complex effects. This is done in Chapter IV.

Table 20
Correlation Between ASVAB Score on Field Artillery and Percentage of Soldiers GO/NO GO Across All Tests

TASKS	Acquisition (N=136)	Retention 1 (N=55)	Retention 2 (N=86)	Retention 3 (N=107)
Measure Quadrant	-.01	.06	.24*	.17
Set/Lay Cannon	.10	.12	-.04	-.16*
Sight Target	.00	-.11	.03	-.08
Micrometer Test	.01	.06	.04	.11
Boresight Telescope	.06	.09	.21*	.11
Emplace/Recover Aiming Posts	-.14*	.11	.03	.02
Emplace Collimator	.07	-.06	.01	.10
Recover Collimator	-.05	.15	.14	.25
Select Ammunition	-.00	-.12	.02	.00
Select Powder	-.01	***	***	-.12
Set Fuze	-.04	***	.17	**
Clear M60 Machinegun	-.03	-.02	.13	.16
Disassemble M60 Machinegun	-.05	.03	.08	.11
Assemble M60 Machinegun	-.02	.32	.21*	.15
Function Check M60 Machinegun	.02	.00	.02	***
Read TM-Breech	-.07	.19	.12	.18*
Disassemble Breech	.12	.29*	.10	.04
Assemble Breech	.14*	.35*	.16	.09
Function Check Breech	.07	-.07	.12	.18*
Install Stakes	.11	-.16	.02	.14
Establish Communication	.20*	.14	.07	.18*
Record Information	-.02	-.15	.20*	.05

* Significant at .05 level.
** Fuze not available for testing.
*** 100% of soldiers passed the task.

Table 21
Correlation Between AVSAB Score on Field Artillery and Percentage of Steps Across All Tests

TASKS	Acquisition (N=136)	Retention 1 (N=55)	Retention 2 (N=86)	Retention 3 (N=107)
Measure Quadrant	-.01	.08	.24*	.18*
Set/Lay Cannon	.10	-.04	.04	-.05
Sight Target	.00	-.03	.02	-.01
Micrometer Test	.01	.05	.08	-.05
Boresight Telescope	.06	.18	.19*	.14
Emplace/Recover Aiming Posts	-.14*	.13	.03	-.02
Emplace Collimator	.07	.06	-.01	.08
Recover Collimator	-.05	.14	.14	.25*
Select Ammunition	.00	.06	.17	.12
Select Powder	-.01	***	***	-.12
Set Fuze	-.04	***	.20*	**
Clear M60 Machinegun	-.03	-.10	.13	.16
Disassemble M60 Machinegun	-.05	.02	-.03	.09
Assemble M60 Machinegun	-.02	.07	.06	.19
Function Check M60 Machinegun	.02	.00	.07	***
Read TM-Breech	-.07	.19	.12	.18*
Disassemble Breech	.12	.15	.07	.03
Assemble Breech	.14*	.18	.18*	.12
Function Check Breech	.07	.08	.16	.10*
Install Stakes	.11	-.16	.01	.09
Establish Communication	.20*	-.19	.05	.12
Record Information	-.02	-.11	.17	.04

* Significant at .05 level.
** Fuze not available for testing.
*** 100% of soldiers passed the test.

Table 22
Correlation Between ASVAB Score on Field Artillery and Mean Time Across All Tests

TASKS	Acquisition (N=136)	Retention 1 (N=55)	Retention 2 (N=86)	Retention 3 (N=107)
Measure Quadrant	.00	-.18	-.16	-.23*
Set/Lay Cannon	-.03	-.34*	-.12	.04
Sight Target	-.10	-.27*	-.22*	-.14
Micrometer Test	.00	-.09	-.24*	-.17*
Boresight Telescope	-.04	-.22	-.29*	-.07
Emplace/Recover Aiming Posts	-.10	-.20	-.06	-.07
Emplace Collimator	-.11	.03	-.04	-.10
Recover Collimator	-.17*	.07	.12	-.07
Disassemble M60 Machinegun	-.06	-.23*	-.13	-.11
Assemble M60 Machinegun	-.03	-.29*	-.20	-.10
Disassemble Breech	-.02	-.30*	-.19	-.08
Assemble Breech	-.22*	-.33*	-.18	-.24*
Install Stakes	.06	.17	.04	-.25*
Establish Communication	.03	-.13	.13	.05

* Significant at .05 level.

Duty Position Assignment

In a combat environment, Artillery crewmen are assigned to very specific jobs. Each soldier has a well-defined position where specific tasks are performed. On the other hand, in a (hypothetical) training environment, individual crewmen are responsible for all crew position tasks. Some units systematically crosstrain crewmen -- all soldiers are given training and practice on all crew positions -- while other units stress individual skills at the crewman's primary duty position.

Since many of the tasks we selected were specific to individual crew positions, we examined the effects of two additional variables on performance: the soldiers' primary duty position and whether or not the soldier had been crosstrained on other positions. We distinguished between Gunner, Assistant Gunner, and Cannoneer #1 positions and the other Cannoneer positions. During the seven month testing period, most (76.1%) soldiers did not change their primary duty positions. Forty-nine soldiers (37.6%) were assigned one of these three positions as their primary duty position. An additional 48 (36.9%) soldiers were crosstrained in these positions. The influence of these assignments will be examined in Chapter IV.

Error Performance

It is useful to examine the specific errors made by soldiers. The step-by-step performance is useful to review since it allows determination of the steps that are most difficult and therefore should be emphasized during training.

Below we will summarize the most frequent errors made on each task.

Measure Quadrant (2 steps): Results from the Acquisition and Retention tests revealed soldiers had to remember to center the bubbles without moving the cannon tube. This first error reveals a conceptual misunderstanding: if you move the tube, you change the quadrant. Most soldiers remembered that they had to center the bubbles, but many did this by simply moving the tube. Second was the physical problem of actually centering the bubbles accurately within 15 seconds, a relatively demanding skill.

Set/Lay Cannon (5 steps): Errors occurred most commonly on two steps -- repeating the quadrant command and centering the longitudinal bubble by elevating or depressing the cannon tube. The former is a procedural step that soldiers may have considered unnecessary in our test situation; the latter is again a relatively demanding physical skill, given the time constraints of the task.

Sight Target (3 steps): Results indicated two sources of difficulty. Two of the three steps are procedural (repeating the range command and repeatedly announcing "Set" after sighting on target); soldiers again may have considered these procedures as unnecessary. The other problem is that soldiers had to mentally determine the correct mil line to put on the target. This involved referring to a chart attached to the howitzer that gives appropriate mils for different ranges. Soldiers had to remember to refer to the chart; furthermore, on our test we forced them to extrapolate between two ranges listed on the chart (e.g., the chart lists ranges of 1000 and 1200 meters; soldiers were given a range of 1100). Some soldiers forgot to refer to the chart; others did, but used the wrong mil line.

Micrometer Test (8 steps): The pattern of errors during the retention tests have led us to speculate that soldiers may have "overproceduralized" this relatively straightforward task. The gunner's quadrant has an index arm calibrated in mils and a micrometer knob calibrated in tenths of mils. The micrometer test is to set either the arm or the knob on zero and the other to one mil, level the quadrant, reverse the settings, and see if the quadrant is still level. Soldiers seem to learn this task in a strictly "rote" fashion. For example, many soldiers set both the knob and the arm to zero, leveled the quadrant, and reset both the knob and the arm to one mil (and reported that the quadrant was not level and therefore malfunctioning). While they memorized the procedure, they did not have sufficient conceptual understanding to avoid these errors.

Boresight Telescope (8 steps): This task was unfamiliar to most of the tested soldiers (fewer than 15% knew how to do the task at all when initially tested). Furthermore, the pattern of errors suggested that soldiers viewed it as a completely arbitrary procedure with no feedback that could help them determine if they were doing the task correctly. Errors of omission and steps out of

sequence were common; in particular, the totally arbitrary step of subtracting 2.3 mils from the elevation (necessitated by the offset bore hole of the M198) was consistently forgotten or miscalculated.

Emplace/recover Aiming Posts (8 steps): During the retention tests the most common error was that soldiers failed to position the near post approximately 50 meters from the howitzer. Again, this may have seemed to be an arbitrary distance for soldiers.

Emplace Collimator (16 steps): Performance was excellent on this task; soldiers passed over 90% of all steps. Only in Retention 2 were any steps passed by fewer than 90% of the soldiers. The problem steps were the procedural ones of opening the lens cover before starting adjustment, and failure to center the azimuth adjustment knob.

Recover Collimator (7 steps): The procedural step of tightening the elevation clamping knob was the only step which any soldiers missed during all three Retention tests.

Select Ammunition (10 steps): The task included selecting both the correct projectile and the correct fuze required by each fire command. In one sense, this is analogous to a paired-associate verbal learning task, where there are specific (arbitrary) responses to each command. Soldiers must memorize the fact that, for example, the M514 fuze is the correct response to "Fuze Victor Tango". In addition, the fuzes themselves do not give any clue to their use.

Select Powder (2 steps): Neither step provided any consistent difficulty for the soldiers.

Set Fuze (2 steps): Again, no real difficulty was found with either step.

Clear M60 Machinegun (4 steps): All steps were passed by at least 86% of the soldiers at each Retention test. The step which was passed by the fewest soldiers varied at each test.

Disassemble M60 Machinegun (6 steps): The most common errors were that soldiers did not separate the operating rod from the bolt or did not separate the spring and the spring guide. Again, these steps may have been viewed as unnecessary by the soldiers.

Assemble M60 Machinegun (7 steps): "Replace cover, tray, and hanger group" was the most common error. Soldiers must remember that the hinge pin goes on the right side and the latch goes on the left; there is nothing on the machinegun itself that could provide a cue to the soldier for these steps.

Function Check M60 Machinegun (5 steps): No steps presented a consistent problem.

Read TM-Breech (1 step): The entire task was to open the training manual to the section on breech maintenance. At Acquisition only 21.4% of the soldiers passed this step, perhaps indicating that this was not a common practice. This view was reinforced when we noticed that it was nearly impossible to put the TM in a position where it would remain open and where the soldier could read it while using both hands to disassemble or assemble the bulky breech mechanism.

Disassemble Breech (5 steps): No steps presented any particular problem.

Assemble Breech (8 steps): The step where most errors were made was to assemble the obturator so that the split rings were 180 degrees apart. Again, there is no apparent reason why the rings should be assembled this way; soldiers apparently forgot this arbitrary procedure.

Function Check Breech (2 steps): Soldiers had only slight problems with each of these steps.

Install Stakes (4 steps): The most difficult part of this task was making the final alignment between the gun guide stake and pantel marking. This involves some degree of physical skill and a steady hand.

Establish Communication (9 steps): Two steps -- "Install the field telephone in an area near the pantel stake and clear of where the howitzer would be positioned," and "Turn INT-EXT switch to INT" -- were passed by the fewest number of soldiers. Both of these steps are non-cued parts of fairly lengthy procedures.

Record Information (2 steps): The step of pacing off the distance from the aiming circle to the Pantel marking stake and recording it was frequently missed. It may have been considered unnecessary to the soldiers.

Summary of Retention Performance

The preceding analyses showed that retention losses did occur between Acquisition and Retention. The tasks showing the greatest losses were largely those characterized as most difficult at Acquisition. However, we found that soldiers performed better on over half (14 out of 22) of the tasks at Retention 3 relative to the previous two testings. In fact, on over half of the tasks performance levels at Retention 3 were greater than those demonstrated at Retention 1. Percentages of soldiers "GO" at Retention 2 were the lowest for any of the three test points. The average number of tasks passed by soldiers at Retention 2 was 12. This compares with an average of 16 for both Retention 1 and 3 and an average of 13 at the first trial of Acquisition.

Retention 1 presented the only clear differences between training conditions and performance measures. Generally we found that a greater percentage of Mastery soldiers passed the tasks. This difference washed out at the subsequent retention points.

We reviewed Percentage of soldiers "GO" on each task step. For the most part only one or two steps per task presented problems for the soldiers. However, on some of the more difficult tasks, such as Sight Target and Disassemble Breech, each of the steps presented the same level of difficulty.

Performance times provided some interesting distinctions. Retention losses occurred between the last trial of Acquisition and the first Retention testing. In other words, more time was required for task completion at Retention testings than at the end of Acquisition. These losses tended to be of the same magnitude, regardless of the amount of time between the two tests. The anomaly to this finding was that "Install Stakes" and "Establish Communication" took less time to complete at the Retention test than at the last trial of Acquisition.

Other factors, e.g., primary duty position, ASVAB scores, and recency of task performance, were also reviewed. Nearly three-fourths of the sample were either assigned to or crosstrained in the Gunner, Assistant Gunner, or Cannoneer #1 positions. With minor exceptions, FA scores and recency of task performance prior to each testing did not provide any strong explanations for task performance.

In Chapter IV, we will consider the combined effects of these factors on performance, controlling for individual differences. Before this, however, we will present a discussion of the User's Decision Aid (UDA), since the task difficulty ratings generated by the UDA were used as predictors of performance.

III. THE USER'S DECISION AID (UDA)

The User's Decision Aid developed in Year II provided a useful tool for predicting task performance based on users' ratings. During Year III, we had three major goals for the further development of the UDA: to build a firm statistical and empirical foundation to support the algorithm using data collected in Year II, to improve the UDA's usefulness and range of applicability, and to validate UDA predictions against Year III 13B data.

Toward the first goal we developed and implemented a procedure to empirically determine the values for each answer option of the UDA questions that best predict actual retention performance. We also developed an empirically based rule that generates proficiency predictions for any time interval.

Toward the second goal, we improved the comprehensibility of the rating procedure, increased the UDA's applicability to other sets of tasks, and incorporated other factors, such as time constraints, into the algorithm. We will discuss these developmental activities in this chapter. Toward the third goal, we conducted a series of multiple regression analyses. This effort is described in Chapter IV.

UDA Development

In Year II, we made three arbitrary assumptions in the construction of the UDA. First, the values assigned to each answer option (e.g., on Question 2, a "good" job/memory aid equals two points, a "poor" job/memory aid equals three points) were not derived empirically. Second, the relative weights for the questions and the rule for combining questions (i.e., equal weights and a straight addition rule) were also arbitrary. Third, the rule that was used to estimate the rate of proficiency loss -- the proportional decrease in the percentage of soldiers able to do a task over time -- while not completely arbitrary, was not statistically derived. (The value of 2.5 percent loss per month per UDA scale score point was derived from the two-month retention data only; extrapolations to four- and six-month retention intervals were made but not evaluated.)

Although our UDA assumptions "worked" for the Year II results (i.e., the task ratings correlated highly with retention performance), we did not have an explicit and defensible rationale for assigning values to answer options. The major reason for this was that we did not have a sufficient "pool" of tasks to allow us to conduct the regression analyses necessary to statistically determine

"best-fit" values. Simply stated, the problem was that we had too few cases (i.e., tasks) for too many predictors.

To increase the number of cases, we combined the 11B task retention data with retention data collected from a sample of Basic Combat Training (BCT) tasks. Briefly, during Year III, project staff were involved in a data collection effort at Fort Jackson, SC. Retention scores for 135 soldiers on BCT tasks were collected about two months after the soldiers had completed BCT. These data increased our pool to a total of 54 tasks: 27 from MOS 11B and 27 from BCT.

To decrease the number of predictors, we conducted a factor analysis of the task dimensions comprising the UDA. Based on the results of that analysis, we were able to reduce the number of UDA task characteristic predictors to five.

Although the resulting data set based on criterion data points for 54 tasks and five predictors was still not ideal, it enabled us to conduct a series of regression analyses. In support of these analyses, the first activity was to obtain UDA ratings for each of the 54 tasks in the criterion pool. We collected these ratings from eight raters, using the Year II scales and questions. Our criterion (performance) measures were Percent Soldiers GO (11B, BCT tasks) and Percent Steps GO (11B tasks) at two-month retention testing. The analyses conducted on these data resulted in empirically based scale values for the answer options within each UDA question (i.e., dimension). They also provided regression weights for each UDA question.

Table 23 illustrates the steps undertaken to determine question weights, scale values for each answer option, and the rule for calculating an overall task score. Details of the procedures for each step are described in the following sections.

Step 1: Find modal response from raters. To simplify the analysis, we needed to select a single set of responses from the eight raters. High interrater reliability had already been established in the Year II UDA, so the pooling of responses across raters could be made without sacrificing predictive power.

Our selection procedure consisted of finding the modal response to each question for each task from the eight raters. This could be thought of as a "majority rules" approach. One judge was chosen to be the tie-breaker in cases where more than one mode existed. This approach was chosen for three reasons: first, mean ratings would not be useful, since we were working with discrete scale values within each question. Second, the mode excludes values at the extremes of the distribution; and third, the different judges represented different perspectives on the ratings --

Table 23
Generating a New UDA Score for a Task

Task: Visual Signals
Two-Month Retention Performance: 26.4%

	1 Job Aids	2 No. of Steps	3 Sequence of Steps	4 Built in Logic	5 Mental Requirements	6 No. of Tasks	7 Difficult to Memorize	8 Physical Demands
Step 1: Find modal response from raters, using old scales (mode matrix)	4	3	0	1	4	4	4	0
Step 2: Replace with corresponding cell means (cell-mean matrix)	70.5	70.0	64.8	74.9	67.3	34.0	28.0	70.3
Step 3: Multiply by question weights (Bs from regression)	x −0.299 −21.1	x 0.220 15.4	x −0.130 −8.4	x 0.848* 63.5	x 0.848* 57.1	x 0.848* 28.8	x 0.848* 23.7	x 0.090 6.3
Step 4: Transform scale values with rounding constants	0	12	10	22	28	0	12	2
Step 5: Sum the results across the row	**= 86**							

* These questions have the same weight, since they were combined in the regression analysis.

some judges were "task" experts, while others were "UDA" experts. We displayed the modal ratings obtained by this procedure in a matrix defined by the UDA questions (columns) and by the 54 tasks (rows). This matrix is referred to as the "mode matrix." The modal ratings for the UDA scales (reduced to eight by combining the mutually exclusive questions one and two) are shown in Table 23 for the Visual Signals task.

Step 2: Replace modes with corresponding cell means. This step was performed by inputting the mode matrix to an analysis of variance (ANOVA) program. We conducted a separate ANOVA for each of the eight questions. The dependent variable for each ANOVA was the Percentage of Soldiers GO measure. The independent variable was the answer options for each question used as a grouping variable. For example, all tasks having a modal rating of "1" on a given question were assigned to the "1" Group; those having a modal rating of "2" were assigned to the "2" Group, etc. We obtained eight separate F statistics.

Cell means (i.e., the means of the criterion retention measure) were generated for each answer option for each question (a total of 29 possible answer options). For example, the first cell mean would be the average of the two-month retention performance measure for those tasks whose modal UDA rating included the first category on the first question, and so on for all the response options in all the questions.

The F statistic describes the significance of the relationship between the UDA modal scores and the retention performance measure. For those questions with significant F values, the pattern of cell means was as expected; tasks with higher modal ratings (e.g., those that were more "difficult") had lower mean performance in terms of the two-month retention measure.

Three of the questions had nonsignificant F values. On Question 1, the availability and quality of job aids, and on Question 8, the physical demands of the task, the modal ratings were highly skewed. Job aids were not used in 49 of the 54 tasks; only one task placed considerable physical demands on soldiers. In these cases the Group sizes were too small to support meaningful ANOVAs. Question 3, the sequential requirements of the task, is in fact a "new" question; it was not contained in the Year II UDA. As will be discussed further below, this question was added due to feedback from UDA users.

It happened that there were no tasks in our sample that had "very complex" mental requirements or that had "excellent" job aids. For these cases, and for options for the questions mentioned above, weights were assigned

arbitrarily. Thus, for "excellent" job aids, we decided that the assigned weight should be equivalent to the sum of the weights of the questions that would be skipped if an excellent job aid was in fact used. This weight, and others arbitrarily assigned, could not be evaluated with the present data base; their evaluations await further empirical research.

With the exceptions noted above, we transformed the mode matrix, replacing each entry with the corresponding cell mean from the ANOVA. For example, on the first question, a modal rating of "2" ("Good" job aids) received a transformed score of "61.3," corresponding to the mean percentage of soldiers GO for all tasks with "Good" job aids. Similarly, modal ratings of "3" and "4" received transformed scores of "63.9" and "70.5," respectively.

From the F statistics associated with the eight one-way ANOVAs, it appeared that most of the predictive power of the UDA was coming from four questions. To explore the relationships among questions further, we conducted a factor analysis of the cell-mean matrix, again with mean two-month Percent Soldiers GO as the dependent variable.

The results of the Factor Analysis supported those of the ANOVA. The factor accounting for the largest proportion of variance could be interpreted as measuring the cognitive demands of the task. Four questions loaded significantly on that factor. We chose to combine these four into a single independent variable, by adding their values together. The other four questions seemed to measure different dimensions of the tasks.

Step 3: Multiply by question weights. We next conducted a regression analysis in which we examined the relationship between the five UDA (predictor) variables and mean two-month retention performance across the 54 tasks. The result of this regression analysis was that 79% of the variance in the criterion measure could be accounted for by the five predictor variables (i.e., the multiple R = .890). This can be compared to the proportion of variance accounted for by the Year-II UDA, which was 66% (multiple R = .810).

The regression analysis also supplied weights for the questions. We used the B's (unstandardized regression coefficients) as weights for the eight questions. For the answer options, the cell means would be multiplied by their corresponding question weights (cf. Table 23).

Steps 4 and 5: Transforming scale values and row-wise addition. While the scale values produced by the preceding steps are "best fits" to the data, they are relatively difficult to work with. From a practical perspective, we would rather not have UDA users adding positive and negative

decimals; therefore, we made a final set of transformations on the scale values to improve their useability.

Our procedure was straightforward: we rounded off the weights to the nearest whole number, then added or subtracted a constant for each question so that the lowest value equalled zero. Then the sum of these additions and subtractions was added to the regression equation constant. These transformations have no effect on the regressions: the regression equation still accounts for 79% of the variance in the criterion measures.

The final step is to add up the eight transformed scores for each task (across each row in the matrix) to arrive at a total UDA score for the task.

Development of a generation rule. The purpose of the UDA is to generate numerical predictions of proficiency. For example, what does a UDA value of "86" mean, and how can this value be used to estimate performance?

For one application -- predicting two-month retention performance -- the translation of the UDA value is straightforward. Since the option weights and combination rule were developed from these data, the two-month retention estimate is the UDA value: i.e., the addition of the scale scores, corrected by a constant; for the example in Table 23, this constant is equal to -40. Thus, a UDA value of "86" translates into a prediction of 86 - 40 = 26 percent proficiency after two months. (The constant used in the final UDA algorithm is equal to -80.)

Other applications, such as predicting four-month retention performance, involve a different set of considerations. For example, a demonstration that the UDA values derived from two-month data correlate with four-month retention does little more than show that the UDA orders tasks correctly; it does not generate proficiency estimates in terms of absolute values. Nor did we want to calculate a different regression equation for each time interval to be predicted. Thus, we wanted to incorporate into the UDA a function that would relate the UDA value and time interval to proficiency scores.

For the Year II UDA, this relationship was expressed as a negative exponential function, with the proficiency prediction decreasing at the rate of 2.5% per month per UDA scale score. The value of the constant was selected to maximize the "fit" with the two-month retention data (MOS 11B) and to enable us to generate predictions for other time intervals. We did not evaluate the accuracy of this function for Year-II data beyond the two-month retention scores, primarily because the four-month and six-month retention data

did not show systematic decreases. We felt that the Year III 13B retention data would be precise enough to be used in developing and evaluating an empirically-based generation rule.

We followed an iterative procedure: we hypothesized a function, generated predictions for two- and four-month retention, compared actual and predicted results, hypothesized a different function, etc. Comparisons were made in terms of the obtained correlation and absolute and arithmetic error between actual and predicted scores. The only constraints we placed on the hypothesized function was that it be asymptotically zero along the "performance" axis.

We tested several dozen hypotheses. The best fitting function -- the one that had the highest correlation and smallest absolute and algebraic difference -- is as follows:

$$\text{Predicted proficiency for week } Y = 100 \times \left(\sqrt[8]{\frac{\text{UDA}}{100}} \right)^{Y}$$

The rule is: divide the UDA value (after subtracting the constant) by 100; take the eighth root; raise the result to the Y^{th} power; multiply by 100. For two months, $Y = 8$, and the formula reduces to just the UDA score, as mentioned above.

When we used this rule to generate predictions for two- and four-month proficiency and compared the predictions to the actual data (i.e., 13B Retention 1 and Retention 2 GO/NO GO percentages for 22 tasks), we obtained a correlation of $r = 0.83$; the mean predicted score was 67.26 (over all tasks), while the actual mean was 66.75. Thus, the absolute error was less than one half of one percent per task.

Revisions of the UDA

One of our goals during Year III was to improve the comprehensibility and useability of the UDA rating procedure. During the year, we had several opportunities to interact with actual and potential users of the UDA. Primarily as a result of these interactions, several changes were made in the questions and answer options.

For example, we found that users had difficulty with Question Four ("Do the steps tend to follow a natural sequence in which completing one step suggests what the next step should be?"). Therefore, we decided to separate this into two "simpler" questions: "Are the steps in the task required to be performed in a definite sequence?" and "Does

the task have any built-in logic so that you know you are doing it correctly?" Similarly, we modified the language of several of the other questions and answers. While we conducted no formal reliability analyses, users of the different versions of the UDA found the rewritten version to be the more comprehensible.

Another change resulted from statistical analyses of the MOS 13B retention data. We found that the predicted and actual scores differed significantly for a number of tasks, specifically those tasks with time limits. We were predicting higher levels of proficiency than were actually observed for tasks in which soldiers were exceeding the time standards. For example, many soldiers took longer than the specified time limit when measuring the quadrant. Thus, we tested the effect of adding a question to the UDA: "Does the task have a time limit for its accomplishment?"

To determine weights for answer options, we rerated all 11B, 13B and Common Soldier tasks, and repeated Steps 1-5 (discussed above). These weights are used in the current version of the UDA.

The Current UDA

Below are the questions, options and scale values of the current UDA. For a detailed description of this information, refer to Rose, Radtke, Shettel, and Hagman (1984).

Question 1. Are job or memory aids intended to be used in performing this task?

Scale Value

- 1 • Yes.
- 0 • No.

Question 2. How would you rate the quality of the job or memory aid?

Scale Value

56	• Excellent. Using the job/memory aid, a soldier can do the task correctly with no additional information or help.
25	• Very Good. With the job/memory aid, a soldier would need only a little additional information to complete the task.
2	• Marginally Good. Even with the job/ memory aid, a soldier would need some additional information to complete the task.
1	o Poor. Even with the job/memory aid, a soldier would need a great deal of additional information in order to complete the task.

Question 3. How many steps are required to do the task?

Scale Value

25	• One step.
14	• Two to five steps.
12	• Six to ten steps.
0	• More than ten steps.

Question 4. Are the steps in the task required to be performed in a definite sequence?

Scale Value

10	• None are.
5	• All are.
0	• Some are and some are not.

Question 5. Does the task have a built-in logic so that you can tell if you are doing it correctly?

Scale Value

22	• Has built-in logic for all steps.
19	• Has built-in logic for most steps.
11	• Has built-in logic for only a few steps.
0	• Has no built-in logic.

Question 6. Does the task have a time limit for its completion?

Scale Value

40	• There is no time limit.
35	• There is a time limit, but it is fairly easy to meet under test conditions.
0	• There is a time limit and it is difficult to meet under test conditions.

Question 7. What are the mental or thinking requirements of this task?

Scale Value

37	• Almost no mental requirements.
28	• Simple mental requirements.
3	• Complex mental requirements.
0	• Very complex mental requirements.

Question 8. How many facts, terms, names, rules or ideas must a soldier memorize in order to do the task?

Scale Value

20	• None (or the job/memory aid provides all necessary information).
18	• A few (1 - 3).
13	• Some (4 - 8).
0	• Very many (more than 8).

Question 9. How hard are the facts, terms, etc., to remember?

Scale Value

34	• Not applicable - there are none to remember or the job or memory aid provides all of the needed information.
31	• Not hard at all - the information is simple.
12	• Somewhat hard - some of the information is complex.
0	• Very hard - the facts, rules, terms, etc., are technical or specific to the task and must be remembered in exact detail.

Question 10. What are the motor skill demands of the task?

Scale Value

2	• None.
0	• Small but noticeable amount of motor skill required.
16	• Considerable amount of motor skill needed.
3	• Very great demand for motor skill.

IV. PREDICTING PERFORMANCE

Introduction

The preceding chapter described development and refinement of a UDA. This chapter discusses its validation: Do performance predictions generated by the UDA correspond to empirical results? The empirical results used for this validation are the 13B data presented in Chapter II, since they were not used in the analytic development of the weights for the UDA answer options.

Thorough understanding of the 13B retention data also is important. As already discussed in Chapter II, there were many potential influences on performance. Some of these stemmed from experimental manipulations (e.g., Mastery versus Proficiency training, number of retention tests a soldier took). Others stemmed from a variety of individual difference variables, including a soldier's background (e.g., his ASVAB scores, duty position, training history, etc.), events occurring during the retention intervals (e.g., individual training, unit exercises, etc.), and the interactions among these variables. Some of these variables are potentially important in their own right (i.e., independent of the UDA validation and the specific 13B context), with possible implications for Army selection, classification, and training decisions. Others are of less general interest but are nonetheless of importance to Field Artillery personnel.

Thus, this chapter has three major sections. First, we present analyses concerned specifically with the UDA validation: How accurately do UDA predictions correspond to actual performance? Second, we compare UDA to other procedures: Are UDA predictions superior to other approaches that might be used to predict proficiency levels? Third, we present analyses aimed at teasing apart the various influences on retention performance: Controlling for as many other potential influences as possible, what is the effect of Mastery versus Proficiency training on retention? Does mode of training (i.e., Mastery versus Proficiency) interact with retention interval (i.e., does the effect change over time)? To what extent do individuals' ASVAB scores covary with retention performance? To what extent is performance affected by other influences, such as intervening practice, previous testing, or other background variables?

Predicting Performance: UDA Validation

To address the first set of questions, we used task difference variables (i.e., information about differences among the entire set of tasks) to predict performance on each 13B task. The basic question was whether the 13B UDA ratings reliably distinguished among tasks in terms of the Percent Soldiers GO or the average Percent Steps GO for each task at selected retention intervals.

The UDA ratings were generated using the algorithm described in Chapter III. Five members of the project staff rated each task. Modal values were calculated for each UDA question to represent group consensus, and these question values were summed to produce a summary score for each task. The summary scores were then converted to predicted Percent Soldiers GO for each task at each Retention test, again using the procedure described in Chapter III. These predictions and the corresponding retention data (Percent Soldiers GO) are shown in Table 24 for 22 13B tasks. (As opposed to previous tables, the tasks in Table 24 are ordered from high to low on the basis of their predicted performance.)

We calculated Pearson product-moment correlations between actual and predicted scores for both Percent Soldiers GO (i.e., Table 24) and Percent Steps GO at each retention test. These correlations were as follows:

	% SOLDIERS GO	% STEPS GO
Retention 1	0.91	0.83
Retention 2	0.61	0.72
Retention 3	0.71	0.70

All of the above correlations are statistically significant ($p < .01$). It is important to repeat that these 13B tasks were not used in the development of the UDA algorithm described in Chapter III; thus, these correlations represent a "true" test of the validity of the UDA.

As shown in Table 24, there were differences between actual and predicted scores across the tasks: as indicated by the means at the bottom of the Table, predicted scores were about four points lower than actual scores at Retention 1, about seven points lower at Retention 2, and

Table 24
Predicted and Actual Performance: Percent Soldiers GO

	RETENTION 1		RETENTION 2		RETENTION 3	
TASK	ACT.	UDA	ACT.	UDA	ACT.	UDA
Func. Check Breech	95.0	94	70.8	88	79.6	83
Select Powder	100.0	94	100.0	88	99.1	83
Recover Coll.	96.6	89	57.3	79	91.2	70
Disassemble M60	79.7	84	44.3	71	92.9	59
Emplace Aim. Posts	76.4	84	52.8	71	98.2	59
Assemble Breech	94.8	83	72.1	69	86.6	57
Set Fuze	100.0	83	65.9	69	----	57
Clear M60	90.0	82	85.4	67	99.1	55
Install Stakes	76.7	80	60.7	64	85.8	51
Disassemble Breech	90.0	79	92.1	62	96.4	49
Func. Check M60	98.3	78	95.5	61	100.0	47
Read TM - Breech	88.3	78	72.2	60	78.1	47
Establish Commo	76.7	75	61.8	56	84.1	42
Assemble M60	83.3	71	82.0	50	87.6	36
Emplace Col.	95.0	65	49.4	42	92.9	27
Select Ammo	63.3	61	09.2	37	30.1	23
Record Information	52.6	55	57.3	30	57.5	17
Measure Quadrant	47.5	54	63.5	29	73.4	16
Sight Target	35.6	51	18.6	26	34.2	13
Set Cannon	59.3	49	50.0	24	68.8	12
Micrometer Test	32.2	33	43.8	11	69.6	04
Boresight Tele.	20.4	32	20.5	10	45.1	03
MEAN	75.1	70.6	60.2	52.9	78.6	40.6
s.d.	24.1	18.1	24.0	23.4	21.1	24.4

38 points lower at Retention 3. Note that the correlations between actual and predicted performance were maintained despite this large difference at Retention 3; this indicates that the UDA continued to order the tasks correctly despite the anomalous increase in actual performance found at Retention 3.

Table 24 also shows some rather large differences between actual and predicted scores for individual tasks (e.g., Emplace Collimator, Function Check M60). However, in general there is good agreement. It might have been expected that the predicted scores would be lower than actual scores, given the influences on performance discussed in Chapter II; these influences (e.g., practice, Mastery training) would tend to inflate observed retention scores. It is impossible to tell whether the differences shown in Table 24 stem from imprecision in the UDA or from confoundings in the measurement of performance; there are no consistent patterns of differences that could be attributable to systemic deficiencies in the UDA. On the whole, these results offer strong evidence for the validity of the UDA, particularly with respect to its generalizability across different Army occupations.

Predicting Performance: Other Approaches

A second set of analyses addresses the question of the predictive power of the UDA ratings compared to other variables that could be used to predict performance. As previously discussed (Rose, et al., 1983), there are several alternatives to a purely analytic approach based on estimates of task difficulty. For example, one could collect empirical data similar to those collected during our Acquisition Phase. Information on first-trial performance and/or number of trials to reach proficiency are reflections of task difficulty, and, if shown to be related to Retention performance, could be used as the basis for a predictive model. Likewise, one could use information similar to our training and practice data (e.g., recency and frequency of individual training, number of ARTEP or other live-fire exercises, etc.) as Retention performance predictors.

Assuming equal predictive validity (an assumption that will be evaluated below), each of these approaches has its advantages and disadvantages. For example, they differ in terms of the ease with which relevant data could be

collected. UDA ratings are the easiest to collect, since the rating process is entirely analytic. The only requirements are for task-descriptive information and a set of subject-matter experts to serve as raters. The alternative of obtaining data on soldiers' task experience would require at least access to their individual Job Books or individual soldier interviews. The alternative of collecting task performance data would be the most difficult, assuming that it is not routinely done. Such an approach would require development of tests, training of scorers, setting up of test facilities, etc.

Alternative approaches to predicting Retention performance also differ in the generalizability of their predictions. It is highly unlikely that one could use Acquisition performance data from the tasks in one MOS to predict retention performance on tasks in a different MOS. Similarly, use of practice and training information would likely have limited applicability across MOSs.

Nevertheless, we investigated two alternative approaches to predicting Retention performance. The predictor variables used were (a) Army training (i.e., practice) information, and (b) actual soldier performance at Acquisition.

The Army Training predictor variable was an average of the ARTEP/Live Fire and Individual Training variables collected from soldier self-reports and Job Book information (see Chapter II and Appendix D). The ARTEP/Live Fire variable was scored as the number of either ARTEP or Live Fire exercises, summed across Retention periods. For example, those soldiers attending Retention 2 who reported at least one ARTEP or Live Fire exercise prior to their test received a "one" for the ARTEP/Live Fire variable; soldiers at Retention 3 who reported either exercise prior to Retention 2 and again prior to Retention 3 were assigned a "two." Individual Training -- whether or not the soldier had received training during the retention period -- was scored similarly. (Using presence versus absence, as opposed to the actual frequency reported, resulted in less skewed distributions for both the ARTEP/Live Fire and Individual Training variables.)

The Army Training variable was an average of the ARTEP/Live Fire and Individual Training variables. Each task was assigned a value by computing an average score for all soldiers. The resulting score was a composite that

captured the accumulated training exercises and individual training.

The Acquisition Performance variable was the Percent Soldiers GO or Percent Steps GO dependent measure (averaged across soldiers) for each of the 22 tasks at first-trial Acquisition. Values for the Acquisition variable were calculated for each subset of soldiers tested at a particular Retention period. Thus, for example, the Acquisition data used for predicting Retention 1 are not based on the same number of soldiers as the Acquisition data used for predicting Retention 2.

We considered three predictor variables for each task: the UDA rating, the Army Training score, and the Acquisition Performance score. We used step-wise regression analyses to examine the relationships between the predictor variables and the two criterion measures. In one set of step-wise regression analyses the UDA variable was entered first, followed by the Army Training variable. In the second set the UDA variable was entered first, followed by the Acquisition Performance variable. In addition to generating zero-order correlations between the predictors and the retention data, the step-wise procedure provided two other coefficients of interest -- Beta weights and Δr^2s.

Table 25 summarizes the results. With but two exceptions, all three variables correlate significantly ($p < .05$) with performance at all retention intervals. Based upon the magnitude of these correlations, either the UDA score or Acquisition Performance could be used to predict Retention performance with fair to excellent accuracy, depending upon the Retention period. Correlations are highest for Retention 1, and lowest for Retention 2.

The Beta weights shown in Table 25 represent the relative contributions of pairs of variables in predicting Retention performance. The Beta weight is not affected by the order in which variables are entered into the regression. The Beta weights thus answer the question regarding which variable is the "better" predictor, UDA or an alternative.

The UDA rating is a better predictor of both performance measures at Retention 1; it is also the better predictor for the Percent Steps GO dependent measure at

Table 25
Zero-Order Correlations and Multiple Regression Results

	Zero-Order Correlations		% Soldiers GO		% Steps GO	
	% Soldiers GO	% Steps GO	Beta	Δr^2	Beta	Δr^2
Retention 1						
UDA	0.91**	0.83**	0.67**	0.82	0.58**	0.69
Acq. Perf.	0.80**	0.76**	0.35**	0.07	0.40**	0.10
UDA			0.87**	0.82	0.79**	0.69
Army Train.	0.40	0.39	0.11	0.01	0.13	0.01
Retention 2						
UDA	0.61**	0.72**	0.34	0.38	0.48*	0.52
Acq. Perf.	0.64**	0.69**	0.41	0.09	0.39*	0.09
UDA			0.58*	0.38	0.62**	0.52
Army Train.	0.43*	0.55*	0.07	0.00	0.16	0.09
Retention 3						
UDA	0.71**	0.70**	0.38	0.50	0.43*	0.49
Acq. Perf.	0.75**	0.71**	0.50*	0.14	0.45*	0.13
UDA			0.65**	0.50	0.54**	0.49
Army Train.	0.44*	0.59**	0.10	0.01	0.31	0.07

*$p < .05$, two-tailed
**$p < .01$, two-tailed

Retention 2. Acquisition Performance is a slightly better predictor for both measures at Retention 3, but UDA is better than the Army Training variable at that same testing.

The Δr^2s shown in Table 25 reflect the proportion of criterion variance explained by each pair of variables. This coefficient is affected by the order in which the variables enter the regression; in the present case, it reflects the amount of information the UDA predicts, including any common variance between the UDA and Acquisition or Army Training variable.

An examination of the Δr^2s reveals that there is a substantial amount of overlap between the UDA and Acquisition or Army Training variables. For example, consider the Percent Soldiers GO variable at Retention 1: the UDA variable accounts for 82% of the variance in the dependent measure; once this variance is "removed," the Acquisition Performance variable accounts for only an additional 7%, despite having a zero-order correlation of $r = 0.80$ with Retention performance; the Army Training variable accounts for virtually no additional variance.

An important point revealed by Table 25 is that even where Acquisition Performance is the better predictor (as determined by its larger Beta weight), the UDA accounts for most of the variance that would have been predicted by Acquisition Performance. In other words, very little information is added by the inclusion of both variables. Naturally, these results would have been different if the Acquisition Performance variable had been entered into the regression before the UDA score: Acquisition Performance would have accounted for approximately 64% of the variance (estimated from the correlation), and the UDA would have accounted for an additional 25% of the variance in the Percent Soldiers GO measure at Retention 1. However, the critical issue for Army planners and trainers is whether the remaining unique variance predicted by Acquisition Performance is worth the significant added cost of field testing a large group of soldiers. We think not.

Predicting Performance: Other Influences

The emphasis in this chapter has been on the development and validation of the UDA. Toward that end we have reported on the relationships between UDA scores and retention performance on a variety of 13B tasks. We have also looked at relationships between Retention performance on those same tasks and other potentially useful predictor variables (i.e., Acquisition Performance, Army Training). In this section we examine the relationships between a variety of other independent variables and Retention performance. These variables characterize individual differences among soldiers who participated in the research. As a consequence, we are interested in the influence of such variables on Retention performance for each of the 22 13B tasks.

Two such variables of primary interest are soldiers' ASVAB scores and the mode of training. Thus, we will look in detail at the ASVAB Field Artillery (FA) Aptitude Area Composite score and the Mastery vs. Proficiency training variable. Finally, we discuss in a general fashion and summarize the results of a set of multiple regression analyses in which we examined the combined influence of several individual difference variables on Retention performance. Toward that end we conducted hierarchical step-wise regressions for 22 tasks, at each Retention period, for two or three dependent measures.

ASVAB FA composite score. As discussed in Chapter II, a variable of particular interest to this project is a soldier's ASVAB-FA score. This Aptitude Area Composite is part of the selection criteria for MOS 13B. However, as we mentioned earlier, the soldiers involved in this project had ASVAB-FA scores that were statistically indistinguishable from scores obtained from a large Army-wide sample of soldiers with comparable entry dates.

We considered using a number of ASVAB composite scores (e.g., AFQT, General Technical, etc.). However, the other scores were correlated with FA and many of them were composites of the same underlying ASVAB subtests. This latter situation introduced some statistical problems (e.g., collinearity) that would make interpretation difficult. For these reasons, therefore, just the ASVAB-FA score was included in the present analyses.

What is the relationship between ASVAB-FA and Retention performance, independent of other variables? There are several ways of addressing this question. One is to examine the zero-order correlations between ASVAB-FA and each performance measure at each Retention test. This gives a "liberal" view of the relationships, since these correlations include the variance shared by ASVAB-FA and other variables. More simply stated, high correlations between ASVAB-FA and performance may be due to the fact that, for example, high-FA soldiers practice more than low-FA soldiers. To get a "pure" indication of the relationship between ASVAB-FA and performance, we would want to eliminate or control for the effects of practice. On the other hand, if having a high ASVAB-FA score in some sense causes soldiers to practice more, then the high correlation would be a true indication of expected performance.

It would be difficult if not impossible to untangle causality from a pattern of correlations or by using other statistical techniques. Therefore, we will present both sides of the coin: we will discuss both the zero-order correlations and the most "conservative" estimate of the relationships -- the partial correlations of ASVAB-FA and performance, with the effects of all other variables removed.

We computed zero-order correlations between ASVAB-FA scores and each performance measure (Percent Soldiers GO, Percent Steps GO, and time) for each task at each Retention test. There were 164 such correlations (22 tasks by three measures by three Retention tests, minus tasks that were not timed and tasks that had no performance variance). Obtained values, presented in Tables 20-22, varied from $r = -0.34$ (Set/Lay Cannon, time, Retention 1) to $r = +0.35$ (Assemble Breech, Percent Soldiers GO, Retention 1). Out of the 164 correlations, 31 were statistically significant ($p < .05$). With few exceptions, all correlations were in the expected direction: higher ASVAB-FA scores were associated with better performance (producing negative coefficients for the time performance measure).

There was no particular pattern discernible from the significant correlations; high correlations were not concentrated at any Retention test or for a particular dependent measure. Similarly, no particular type of task had more significant correlations than any other type of task. In general, the best that could be said about the

relationship between ASVAB-FA and Retention performance is that the number and direction of the correlations support a weak association, particularly for time data at Retention 1.

The more conservative test of the relationship between ASVAB-FA and performance is based on the Beta weights calculated from a multiple regression analysis, where the effects of all other variables on performance have been removed. The "other variables" for these analyses will be discussed more fully in the final section of this chapter; briefly, they included Mastery vs. Proficiency, Army Training, soldiers' primary duty position, number of previous tests, and whether the soldiers received any crosstraining in crew positions other than their primary one.

Again, 164 Beta weights were computed, corresponding to the number of correlations. Out of these, 32 were statistically significant. As opposed to the essentially random pattern of significant zero-order correlations, there was some consistency here; two tasks had significant Beta weights across all measures and for each Retention test. These tasks were Assemble the Breech and Measure the Quadrant. Also, there was a higher concentration of significant Beta weights for the time measure, as opposed to the two accuracy measures. However, despite these consistencies, there were still no easily interpretable relationships between ASVAB-FA and Retention performance.

In summary, one could predict that high-FA soldiers would perform these tasks better than low-FA soldiers; however, this relationship is not strong enough to suggest that a prediction of performance based on a task's UDA rating should be modified, given knowledge of the soldiers' ASVAB-FA scores.

Mastery vs. Proficiency. Similar analyses were conducted for the Mastery-Proficiency variable. Recall that each soldier received extra training (additional trials following correct performance) on half of the tasks. Thus, at each Retention test, half of the soldiers performing each task had received Mastery training and half had received Proficiency training. The differences in performance that resulted from this differential treatment were shown earlier in Tables 16-18.

Again we computed 164 zero-order correlations and Beta weights, one for each task by dependent measure by Retention test combination. For the zero-order correlations, only 16 of the 164 were statistically significant ($p < .05$). The highest positive correlation was $r = .44$ (Record Information, Percent Steps GO, Retention 1), and the highest negative correlation was $r = -.35$ (Set/Lay Cannon, time, Retention 1). Clearly, there was no systematic relationship between type of training and Retention performance. This outcome is similar to what we found when we compared mean levels of Retention performance.

Results were only slightly more encouraging when the Beta weights were examined. Here, 19 of the 164 Beta weights were statistically significant ($p < .05$). Five tasks -- Record Information, Assemble Breech, Select Ammunition, Micrometer Test, and Assemble M60 -- had more than one significant Beta weight.

Given these results and the results presented in Chapter II, we must conclude that the potential benefits of additional training administered at Acquisition did not accrue. Naturally, this conclusion is limited to our operationalization of Mastery training; it is entirely possible that more extensive or intensive training would have had greater positive effects on subsequent Retention performance.

Other independent variables. The final set of analyses was an attempt to untangle the effects of several variables that potentially influenced performance. The strategy was to conduct large-scale multiple regression analyses, including as independent variables any and all measures of individual differences that we believed to be nonredundant and reliable. Dependent variables were again Percent Soldiers GO, Percent Steps GO, and performance time for each of the 22 tasks at each Retention test.

The independent variables included in these analyses were:

- ASVAB FA Composite score
- Mastery vs. Proficiency
- ARTEP/Live Fire (see p. 76)

- Individual Training (see p. 76)
- Primary Duty Position -- Gunner, Assistant Gunner, and Cannoneer #1 received a "1," all other duty positions received a "0"
- Crosstraining -- based on self-report data, whether or not (1 vs. 0) a soldier received training in duty positions other than his primary duty position
- Number of Times Tested During the Experiment

These variables were selected from a larger set of potential predictors. For example, we collected a wide variety of information regarding soldiers' task experiences between Retention tests (see Appendix B) and extensive information about the soldiers themselves (e.g., rank, pay grade). As a preliminary step to the present analyses, intercorrelations among the larger set of potential predictors were calculated, along with descriptive information (mean, standard deviation, skewness, etc.) for each variable. Variables were excluded from further analysis for several reasons. For example, a variable was excluded if it had a high correlation with another variable, or if its distribution was highly skewed, or there was little or no variance in our sample of soldiers on the measure. The remaining variables thus measured different aspects of individual differences among our sample of soldiers.

To reiterate, these analyses were conducted with several goals in mind. First, we wanted to assess the independent effects of these variables on Retention performance, with the ultimate goal being to refine the predictions for specific tasks. In some cases, these effects (if found) could be used by Unit personnel when determining training requirements. For example, if we found that "Crosstraining" improved Retention performance, there would be obvious consequences for training. Another goal was to assess the impact of these variables when any artifacts caused by our experimental treatment were eliminated. For example, our design involved testing some soldiers two or three times during a six-month period; this is not a training strategy that would be used in the Unit. Therefore, if this treatment influenced performance, we would want to statistically "remove" this influence when assessing the effects of other variables.

As might be expected, the results of these analyses were quite complex. One way of summarizing them is shown in Table 26. This table shows the multiple correlations for the variables that were significantly related to performance for each task/measure/Retention test combination. Only those multiple correlations that were significantly greater than zero are included.

The data indicate that some of the variance in Retention performance can be accounted for by our set of individual difference predictor variables. There are significant multiple correlations associated with most tasks. For some tasks -- Measure Quadrant, Sight Target, Micrometer Test, Assemble the Breech, and Record Information -- the multiple correlations are significant for practically all dependent measure/Retention test combinations. At least half of the tasks have significant multiple correlations at each Retention test for the Percent Soldiers GO and time measures, and at Retention 3 for the Percent Steps GO measure. In nearly 70% of the task/Retention test combinations, there are significant multiple correlations with the time measure.

On the other hand, the magnitude of these multiple correlations is at best moderate; of the 95 significant ones, roughly half (49) account for less than 10% of the variance observed in the performance measure. In fact, only eleven accounted for more than 20% of the variance; at best (Assemble Breech, Retention 2, time, and Set/Lay Cannon, Retention 1, time), the individual difference variables accounted for 32% of the variance (multiple correlation = .57).

To conclude this discussion, Table 27 shows the specific variables that were significantly related to performance in each cell. As can be seen, many of the effects in specific cells are complex; there are two-way and three-way interactions, negative relationships, and suppressor effects (i.e., variables that enhance the relationship between another variable and performance, while not itself being related to performance).

The gist of these analyses is that there were many influences on Retention performance other than the particular variables of interest to this project (i.e., Proficiency-Mastery, ASVAB-FA). However, when one considers the range of variables included in these

Table 26
Multiple Regression Results: Significant Multiple Correlations

	Percent Soldiers GO			Percent Steps GO			Time		
	Retention 1	Retention 2	Retention 3	Retention 1	Retention 2	Retention 3	Retention 1	Retention 2	Retention 3
Measure Quadrant	34	37	44	28	27	43	35	46	51
Set/Lay Cannon	34	25	—	—	25	—	57	—	—
Sight Target	33	—	23	—	—	38	27	36	22
Micrometer Test	40	25	23	35	—	26	37	37	23
Boresight Telescope	—	—	23	—	—	23	28	29	29
Emplace/Recover Aiming Posts	—	—	20	—	25	—	42	—	25
Emplace Collimator	—	—	—	—	—	19	—	43	25
Recover Collimator	—	—	45	—	—	45	28	25	—
Select Ammunition	—	—	24	—	—	33	NOT TIMED		
Select Powder	—	—	22	—	—	22	NOT TIMED		
Select Fuze	—	28	—	—	35	—	NOT TIMED		

Note: significance is at the .05 level

Table 26 (continued)
Multiple Regression Results: Significant Multiple Correlations

	Percent Soldiers GO			Percent Steps GO			Time		
	Retention 1	Retention 2	Retention 3	Retention 1	Retention 2	Retention 3	Retention 1	Retention 2	Retention 3
M60 Machine Gun									
Clear	—	34	22	—	35	22		NOT TIMED	
Disassemble	28	30	—	—	30	—	40	—	—
Assemble	51	24	22	—	—	32	44	—	—
Function Check	—	—	—	—	—	—		NOT TIMED	
Breech Mechanism									
Read Tm	—	23	35		One Step			NOT TIMED	
Disassemble	29	24	—	—	—	—	30	—	36
Assemble	35	55	—	30	57	—	30	46	36
Function Check	—	30	34	—	28	34		NOT TIMED	
Prepare Position									
Install Stakes	32	—	24	31	—	26	—	27	26
Communicate	23	—	25	25	—	—	—	22	—
Record Information	35	37	44	37	23	50		NOT TIMED	

Note: significance is at the .05 level

Table 27
Multiple Regression Results: Significant Predictors

	Percent Soldiers GO			Percent Steps GO			Time		
	Retention 1	Retention 2	Retention 3	Retention 1	Retention 2	Retention 3	Retention 1	Retention 2	Retention 3
Measure Quadrant	P	A, B	A, B, *	B	A	A, B, *	P	A, B, C	A, B, *
Set/Lay Cannon	B	B	—	—	B	—	A, B, P	—	—
Sight Target	B	—	C	—	—	C, *	A	A, P	*
Micrometer Test	I	M	B	I	—	P	I, P	A, M_A	B
Boresight Telescope	—	—	B	—	—	B	A, m_A	A	B
Emplace/Recover Aiming Posts	—	—	—	—	—	—	P	—	P
Emplace Collimator	—	—	—	—	—	—	—	B	*
Recover Collimator	—	—	A, $\underline{C}$, *	—	—	A, $\underline{C}$, *	B, p_B	C	—
Select Ammunition	—	—	M	—	—	M, *		NOT TIMED	
Select Powder	—	—	C, *	—	—	C, *		NOT TIMED	
Select Fuze	—	B, *	—	—	A, M_A	—		NOT TIMED	

Examples:

M_A = "M" significant predictor and suppressor for "A"

m_A = "m" nonsignificant predictor but suppressor for "A"

$\underline{C}$ = "C" significant predictor and inverse relation with criterion performance

$\underline{c}_A$ = "c" nonsignificant predictor, inverse relation with criterion performance, and suppressor for "A"

* = testing effect

Note: significance is determined to the .05 level

Legend:

A = ASVAB-FA

B = ARTEP/Line Fire

C = Crosstrained

I = Individual Training

M = Mastery vs. Proficiency

P = Duty Position

Table 27 (continued)
Multiple Regression Results: Significant Predictors

	Percent Soldiers GO			Percent Steps GO			Time		
	Retention 1	Retention 2	Retention 3	Retention 1	Retention 2	Retention 3	Retention 1	Retention 2	Retention 3
M60 Machine Gun									
Clear	—	A, B	A, m_A	—	A, C, $\underline{b}_{AC}$	A, M_A		NOT TIMED	
Disassemble	P	*	—	—	*		A, I, M_{AI}	—	—
Assemble	A, M	A, $\underline{p}_A$	$\underline{P}$	—	—	A, M	A, $\underline{C}$, I, p_{AI}	—	—
Function Check	—	—	—	—	—	—		NOT TIMED	
Breech Mechanism									
Read Tm	—	$\underline{M}$	A, $\underline{p}_A$, c_A*		One Step			NOT TIMED	
Disassemble	A	M	—	—	—	—	A	—	B
Assemble	A	A, $\underline{C}$, I_{AC}, M_{ACI}	—	M	A, $\underline{C}$, I_{AC}, $\underline{M}_{ACI}$	—	A	A, I, $\underline{M}_{AI}$	A, *
Function Check	—	B	P, B, $\underline{c}_B$	—	B	P, B, $\underline{c}_B$		NOT TIMED	
Prepare Position									
Install Stakes	$\underline{P}$	—	$\underline{C}$	$\underline{P}$	—	$\underline{C}$, $\underline{P}$	—	B	A, *
Communicate	$\underline{C}$	—	A	$\underline{C}$, b_c	—	—	—	B, $\underline{I}_B$	—
Record Information	M	A, *	M	M	A, m_A	T_3, T_2, M		NOT TIMED	

Examples:

M_A = "M" significant predictor and suppressor for "A"

m_A = "m" nonsignificant predictor but suppressor for "A"

$\underline{C}$ = "C" significant predictor and inverse relation with criterion performance

$\underline{c}_A$ = "c" nonsignificant predictor, inverse relation with criterion performance, and suppressor for "A"

* = testing effect

Note: significance is determined to the .05 level

Legend:

A = ASVAB-FA

B = ARTEP/Line Fire

C = Crosstrained

I = Individual Training

M = Mastery vs. Proficiency

P = Duty Position

analyses, the result (i.e., that only a moderate amount of performance variance was accounted for) is rather surprising. Especially when compared to the results reported above concerning the relationship between the UDA ratings and Retention performance, the implication is that by far the biggest determinant of Retention performance is the characteristics of a task, especially those characteristics measured by the UDA. This means that the UDA alone, without embellishments and qualifications concerning soldiers' abilities, experience, etc., could provide good predictions of Retention performance.

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APPENDIX A

HANDS-ON TESTS FOR TASKS SELECTED FOR RETENTION EXPERIMENT

PREPARE A POSITION TO RECEIVE/EMPLACE A HOWITZER

Equipment Required To Set Up Station and Conduct Test

2	Gun guide stakes
2	Pantel marking stakes
2	M2 compasses
2	DR8, with field wire
3	TA-312/PT field telephones, with batteries
1	SB-16 switchboard
2	Screwdrivers, flattip
1	Aiming circle
	Paper and pencil
2	Tent stakes
2	Hammers

Procedures To Set Up Station

1. Orient aiming circle on open area. Determine a reasonable azimuth of fire to tell soldiers in instruction.

2. Lay out following equipment near aiming circle:

   a. Pantel marking stakes
   b. Gun guide stakes
   c. Hammers
   d. TA-312/PT field telephones, with batteries
   e. Screwdrivers
   f. M2 compasses
   g. DR8 with field wire
   h. Paper and pencil

3. Set up switchboard about 5 meters from aiming circle.

Procedures To Be Performed Before Testing Each Soldier

1. Return equipment used by soldier to aiming circle.

2. Offset TA-312/PT:

   a. Remove batteries.

   b. Set buzzer control knob to LOW.

   c. Place INT-EXT to EXT.

   d. Place circuit selector switch to CB.

Scorer: _____ Soldier: _____

Date: _____

SCORESHEET

PREPARE A POSITION TO RECEIVE/EMPLACE A HOWITZER

INSTRUCTIONS TO SOLDIER: During this test you will act as a gun guide preparing a position to receive a howitzer. The equipment you will need is by the aiming circle. You may record information on the tablet (hand soldier the paper and pencil). You are gun _____. Your azimuth of fire is _____. Emplace the pantel marking stake (designate area about 30 meters away at an oblique angle.)

TALK THROUGH _____

PERFORMANCE MEASURES	GO	NO-GO	COMMENTS
Install Stakes			
1. Emplaced pantel marking stake in area designated. (Must not move stake while alining gun guide stake.)	____	____	_____
2. Sighted through M2 compass to determine the azimuth of fire from pantel marking stake.	____	____	_____
3. Emplaced gun guide stake along azimuth of fire, at least three paces from pantel marking stake.	____	____	_____
4. Final alinement between gun guide stake and pantel marking stake ± 20 mils of directed azimuth.	____	____	_____
Establish Communication			
5. Installed jack in switchboard position number for howitzer.	____	____	_____
6. Installed field telephone in area near pantel stake clear of area where howitzer would be positioned (from gun guide stake, left of pantel stake).	____	____	_____
7. Tied wire to tent stake at telephone.	____	____	_____
8. Connected wire to binding posts of tele phone.	____	____	_____
9. Installed batteries (one + up: one + down).	____	____	_____
10. Turned selector switch to LB.	____	____	_____

SCORESHEET (Cont'd.)

PREPARE A POSITION TO RECEIVE/EMPLACE A HOWITZER

PERFORMANCE MEASURES	GO	NO-GO	COMMENTS
11. Turned INT-EXT switch to INT.	____	____	____
12. Performed ring test by holding receiver in cradle while turning crank.	____	____	____
13. Conducted commo check with aiming circle telephone.	____	____	____
Recorded Information			
NOTE TO SCORER: Scorer Assistant should tell soldier the deflection whenever he asks for it. If he does not ask, have the Scorer Assistant give the deflection as part of the commo check.			
14. Recorded deflection from aiming circle to Pantel marking stake.	____	____	____
15. Paced off distance from aiming circle to Pantel marking stake and recorded it.	____	____	____

TIME		Initial	Retest
1. Minutes to install stakes:	First Test	____	____
	Repetition 2	____	____
	Repetition 3	____	____
2. Minutes to establish communication:	First Test		
	Repetition 2	____	____
	Repetition 3	____	____

PM NO-GO Repetition 2: Install Stakes (1-4) _____

Est. Commo (5-13) _____

Rec. Info (14, 15) _____

PM NO-GO Repetition 3: Install Stakes (1-4) _____

Est. Commo (5-13) _____

Rec. Info (14, 15) _____

EMPLACE/RECOVER AIMING POSTS
EMPLACE/RECOVER COLLIMATOR

Equipment Required To Set Up Station and Conduct Test

M198 howitzer
M137 panoramic telescope (mounted)
Set of aiming posts (four sections - complete)
Night-lighting device for aiming posts
Scorer assistant to act as gunner
M1A1 collimator

Procedures To Set Up Station

1. Position howitzer in location that has at least 100 meters of level terrain.
2. Orient howitzer on direction of fire with tube in center of traverse at load elevation.
3. Orient pantel on direction of area where aiming posts will be emplaced.

Procedures To Be Performed Prior To Testing Each Soldier

1. Place one set of aiming posts (four short sections) to left side of howitzer.
2. Place night-lighting devices next to aiming posts.
3. Turn azimuth adjusting knob on collimator fully left or fully right. During the test, offset the knob before the soldier recovers the collimator.
4. Place collimator to left side of howitzer in stowed position.

Scoring Procedures

Aiming Post

1. Score the aiming post test from the panoramic telescope. Give the soldier signals for the adjustment.
2. For PM 3 and 4, count the steps the soldier takes to the emplacement point.
3. If the soldier gets a NO-GO on the aiming post test, tell him what he did wrong as soon as he finishes. But give the collimator test before you retest him on the aiming post. (This is to give him time to recover his breath.)
4. Score the collimator test by the soldier while the scorer assistant acts as gunner.

Collimator

5. For PM 10, the soldier may not need to center the knob. If he can aline the collimator without centering the knob, enter NA for the PM.
6. If the collimator is alined without any adjustment, have the gunner aline five mils left or right.

Scorer: _____ Soldier: _____

Date: _____

SCORESHEET

EMPLACE/RECOVER AIMING POSTS

INSTRUCTIONS TO SOLDIERS: For this test you must emplace and recover aiming posts. Assume we will occupy this position for next 24 hours. You will have two minutes to emplace the aiming posts. I will act as Gunner. Begin.

PERFORMANCE MEASURES	GO	NO-GO	COMMENTS
1. Prepared two short posts for far post.	____	____	_____
2. Attached night-lighting device to top of each aiming post.	____	____	_____
3. Positioned near post (short section) approximately 50 meters from howitzer (33-36 steps).	____	____	_____
4. Positioned far post (long section) same distance (± 3 steps) from short post as short post was from howitzer.	____	____	_____
5. Turned night-lighting device on far post toward howitzer.	____	____	_____
6. Emplaced far post	____	____	_____
7. Emplaced near post at direction of gunner.	____	____	_____
8. Turned night-lighting device on near post toward howitzer.	____	____	_____
9. Completed emplacement within two minutes.	____	____	_____

NOTE TO SCORER: After soldier completes emplacing near post, give verbal command RECOVER AIMING POSTS.

10. Pulled posts from ground.	____	____	_____
11. Disassembled far posts.	____	____	_____
12. Removed night-lighting devices.	____	____	_____
13. Replaced posts and devices in stowed position.	____	____	_____

TIME		Initial	Retest
Minutes to emplace aiming posts:	First Test	_____	_____
	Repetition 2	_____	_____
	Repetition 3	_____	_____

PM NO-GO Repetition 2 _____

PM NO-GO Repetition 3 _____

Scorer: _____ Soldier: _____

Date: _____

SCORESHEET

EMPLACE/RECOVER COLLIMATOR

INSTRUCTIONS TO SOLDIER: For this test you must emplace and recover the collimator. The assistant will act as the Gunner. First emplace the collimator. You have two minutes. Begin.

PERFORMANCE MEASURES	GO	NO-GO	COMMENTS
Emplace Collimator			
1. Set up 4 to 15 meters from pantel and more than 45° from muzzle end.	____	____	_____
2. Unlatched leg holding straps and lowered legs. (Does not have to extend legs.)	____	____	_____
3. Removed cover.	____	____	_____
4. Placed cover under tripod-closed end toward howitzer.	____	____	_____
5. Loosened azimuth clamping knob.	____	____	_____
6. Loosened cross-level clamping knob.	____	____	_____
7. Loosened elevation clamping knob.	____	____	_____
8. Placed collimator in horizontal position.	____	____	_____
9. Opened lens cover before gunner started adjustment.	____	____	_____
10. Centered azimuth adjustment knob (if needed).	____	____	_____
11. Alined front and rear sights of collimator on panoramic telescope (rough lay).	____	____	_____
12. Tightened azimuth clamping knob.	____	____	_____
13. Tightened elevation clamping knob.	____	____	_____
14. Leveled cross-level bubble after closing azimuth and elevation clamping knobs.	____	____	_____
15. Tightened cross-level clamping knob.	____	____	_____
16. Alined collimator by rotating azimuth adjusting knob following gunner's signals.	____	____	_____
17. Emplaced collimator within two minutes.	____	____	_____

SCORESHEET (Cont'd.)

EMPLACE/RECOVER COLLIMATOR

PERFORMANCE MEASURES	GO	NO-GO	COMMENTS
INSTRUCTIONS TO SOLDIER: Now recover the collimator. You have one minute.			
18. Loosened elevation clamping knob.	____	____	____
19. Placed collimator in vertical position.	____	____	____
20. Tightened elevation clamping knob.	____	____	____
21. Fastened snap.	____	____	____
22. Placed cover on collimator and closed snaps.	____	____	____
23. Folded legs.	____	____	____
24. Resnapped holding straps.	____	____	____
25. Recovered collimator within one minute.	____	____	____

NOTE TO SCORER: Returning collimator to the howitzer is not timed.

TIME		Initial	Retest
Minutes to emplace collimator:	First Test	____	____
	Repetition 2	____	____
	Repetition 3	____	____

PM NO-GO Repetition 2 _____

PM NO-GO Repetition 3 _____

PERFORM OPERATOR MAINTENANCE ON THE M60 MACHINEGUN (ASSEMBLY/DISASSEMBLY)

Equipment Required To Set Up Station and Conduct Test

M60 machinegun (with bolt)
Small punch or tool in spare barrel bag
Tarpulin

Procedures To Set Up Station

1. Place M60 on tarpaulin with tripod legs open.
2. Place small punch by M60.

Procedures To Be Performed Before Testing Each Soldier

1. Insure M60 is returned to operational condition if it does not pass function check.
2. Set safety on SAFE.

Procedures To Conduct the Test

1. If the soldier does not remove the components required for the eight groups, mark NO-GO for the incomplete group and tell him to remove the components.
2. If the soldier gets a NO-GO on Clear or Disassemble, give the remediation after the weapon is assembled.
3. Treat this test like three tasks: Clear and Disassemble; Assemble; and Function Check. If the soldier gets a NO-GO on one part but not the others, he should repeat only the major segment where he made the error. If necessary, you must assemble or disassemble the M60 to get it ready for the soldier.

Scorer: _____ Soldier: _____

Date: _____

SCORESHEET

PERFORM OPERATOR MAINTENANCE ON THE M60 MACHINEGUN
(ASSEMBLY/DISASSEMBLY)

INSTRUCTIONS TO SOLDIER: During this test you will disassemble and assemble the M60 machinegun. First, disassemble the machinegun into its eight major groups. You will have four minutes. Begin.

PERFORMANCE MEASURES	GO	NO-GO	COMMENTS
Clear			
1. Raised cover.	____	____	_____
2. Placed safety to FIRE and cocked weapon.	____	____	_____
3. Visually checked chamber.	____	____	_____
4. Let bolt slide forward while pulling trigger.	____	____	_____
NOTE TO SCORER: Do not let soldier start disassembly with weapon cocked.			
5. Placed safety to SAFE.	NA	____	_____
Disassemble			
6. Removed the stock group.	____	____	_____
7. Removed buffer and operating rod group. (Must separate: operating rod and bolt; spring and spring guide.)	____	____	_____
8. Removed trigger mechanism group.	____	____	_____
9. Removed barrel group.	____	____	_____
10. Removed forearm assembly.	____	____	_____
11. Removed cover, tray and hanger group. (Must remove cover spring.)	____	____	_____
12. Completed disassembly within four minutes.	____	____	_____

TIME		Initial	Retest
Minutes to disassemble M60 (PM 1-11):	First Test	_____	_____
	Repetition 2	_____	_____
	Repetition 3	_____	_____

PM NO-GO Repetition 2 _____

PM NO-GO Repetition 3 _____

SCORESHEET (Cont'd.)

PERFORM OPERATOR MAINTENANCE ON THE M60 MACHINEGUN
(ASSEMBLY/DISASSEMBLY)

INSTRUCTIONS TO SOLDIER: Now assemble the M60. You have four minutes.

PERFORMANCE MEASURES	GO	NO-GO	COMMENTS
Assemble			
1. Replaced cover, tray, and hanger group. (Hinge pin from right side and latch from the left.)	_____	_____	_____
2. Replaced barrel group.	_____	_____	_____
3. Replaced trigger mechanism group.	_____	_____	_____
4. Replaced bolt assembly.	_____	_____	_____
5. Replaced operating rod group.	_____	_____	_____
6. Replaced buffer assembly.	_____	_____	_____
7. Replaced stock group.	_____	_____	_____
8. Completed assembly within four minutes.	_____	_____	_____
Function Check			
NOTE TO SCORER: If soldier does not do function check on his own, tell him to conduct one.			
9. Placed safety on FIRE and cocked weapon.	_____	_____	_____
10. Put safety on SAFE and pulled trigger (should not fire.)	_____	_____	_____
11. Closed cover before riding bolt forward.	_____	_____	_____
12. Placed safety on FIRE.	_____	_____	_____
13. Let bolt slide forward while pulling trigger.	_____	_____	_____

TIME		Initial	Retest
Minutes to assemble M60 (PM 1-7):	First Test	_____	_____
	Repetition 2	_____	_____
	Repetition 3	_____	_____

PM NO-GO Repetition 2 _____

PM NO-GO Repetition 3 _____

PREPARE SEPARATE LOADING AMMUNITION FOR FIRING

Equipment Required To Set Up Station

Drawings of three projectiles (w/color and nomenclature but without type): HE, WP, Illumination
Drawings in color of fuzes: M557 PD, M564 MTSQ, M565 MT, M514 VT
Drawings in color of white bag and green bag powder charges
105 HE projectile, inert
M563 fuze, mechanical time, inert
M17 fuze wrench
Record of fire forms (DA Form 4513)
Easel
Field table

Procedures To Set Up Station

1. Place drawings on easel.

2. Place projectile, fuze, and wrench on field table.

Procedure To Be Performed Prior To Testing Each Soldier

1. Set fuze to 0.

Procedures To Conduct Test

1. Give the fire commands at real time speed.

2. If the soldier requests SAY AGAIN for any element of the command, announce it again. (Do not score NO- 0.)

3. If the soldier changes a response before you give the next command, score the last response.

Scorer: _____ Soldier: _____

Date: _____

SCORESHEET

PREPARE SEPARATE LOADING AMMUNITION FOR FIRING

INSTRUCTIONS TO SOLDIER: During this test you will do some of the steps associated with preparing separate loading ammunition for firing. I will announce fire commands and you must select the projectile and fuze that are required by each command. You should fill out the Record of Fire form.

PERFORMANCE MEASURES	GO	NO-GO	COMMENTS
BATTERY ADJUST, SHELL-WP LOT-XY, CHARGE-5 GREEN BAG, FUZE-QUICK			
1. Selected WP (light green with red) round.	____	____	_____
2. Selected M557 fuze.	____	____	_____
BATTERY ADJUST, SHELL-HE LOT-XY, CHARGE-3 GREEN BAG, FUZE TIME, TIME 22.6			
3. Selected HE (OD green with yellow) round.	____	____	_____
4. Selected M564 fuze.	____	____	_____
5. Set 22.6 on fuze.	____	____	_____
BATTERY ADJUST, SHELL-ILLUMINATION, LOT-XY, CHARGE-5 GREEN BAG, FUZE TIME, TIME 20.9			
6. Selected Illumination (OD green with white) round.	____	____	_____
7. Selected M565 fuze.	____	____	_____
BATTERY ADJUST, SHELL-HE, LOT-XY, CHARGE-4 GREEN BAG, FUZE VICTOR TANGO, TIME 21.0			
8. Selected HE (OD green with yellow) round.	____	____	_____
9. Selected M514 fuze.	____	____	_____
SELECT THE POWDER			
10. Selected green bag powder.	____	____	_____
11. Selected charge 1-4.	____	____	_____
BATTERY ADJUST, SHELL-WP, LOT-XY, CHARGE-5, GREEN BAG, FUZE TIME, TIME 38.9			
12. Selected WP (light green with red) round.	____	____	_____
13. Selected M564 fuze.	____	____	_____
14. Set 39.9 on fuze.	____	____	_____

PM NO-GO Repetition 2 _____

PM NO-GO Repetition 3 _____

PERFORM GUNNER'S QUADRANT MICROMETER TEST/ BORESIGHT DIRECT FIRE TELESCOPE USING DAP

Equipment Required To Set Up and Conduct Test

M198 howitzer
M138 direct fire telescope
M1A2 gunner's quadrant
Boresight string and tape
Screwdriver, flattip

Procedures To Set Up Station

1. Aline cannon tube on a well-defined distant aiming point (DAP) approximately 1500 meters from howitzer.
2. Attach boresight strings.
3. Mount M138 direct fire telescope.
4. Conduct end for end and micrometer test of gunner's quadrant. If quadrant is not accurate, provide a replacement.

Procedures To Be Performed Before Testing Each Soldier

1. Turn the elevation screw.
2. Off-set the cross-level bubble slightly.

Procedures To Conduct Test

1. Conduct the micrometer test before the boresight test.
2. If the soldier centers the cross-level bubble when he performs the micrometer test, tell him to offset the bubble before he boresights.
3. If the soldier makes an error on the micrometer test, conduct remedial training on the micrometer test before you give the boresight test.

Scorer: _____ Soldier: _____

Date: _____

SCORESHEET

PERFORM GUNNER'S QUADRANT MICROMETER TEST

INSTRUCTIONS TO SOLDIER: For this test you must conduct a micrometer test on the gunner's quadrant. You have one minute. Begin.

TALK THROUGH _____

PERFORMANCE MEASURES	GO	NO-GO	COMMENTS
1. Set index arm to +10 or zero.	____	____	_____
2. Set micrometer to zero or +10 (opposite of index arm setting).	____	____	_____
3. Placed gunner's quadrant on quadrant seats, pointed toward muzzle.	____	____	_____
4. Centered bubble on gunner's quadrant by depressing or elevating tube.	____	____	_____
5. Reversed settings on index arm and micrometer.	____	____	_____
6. Placed gunner's quadrant on quadrant seats, pointed toward muzzle.	____	____	_____
7. Checked bubble on gunner's quadrant without moving tube.	____	____	_____
8. Reported status of micrometer.	____	____	_____
9. Completed micrometer test within one minute.	____	____	_____

TIME		Initial	Retest
Seconds to conduct micrometer test:	First Test	_____	_____
	Repetition 2	_____	_____
	Repetition 3	_____	_____

PM NO-GO Repetition 2 _____

PM NO-GO Repetition 3 _____

Scorer: _____ Soldier: _____

Date: _____

SCORESHEET

BORESIGHT DIRECT FIRE TELESCOPE USING
DISTANT AIMING POINT METHOD

INSTRUCTIONS TO SOLDIER: For this test you must boresight the direct fire telescope using the distant aiming point. The DAP is _____. The boresight strings have been mounted and the tube is alined on the DAP. You have three minutes. Begin.

TALK THROUGH _____

PERFORMANCE MEASURES	GO	NO-GO	COMMENTS
NOTE TO SCORER: Soldier may take reading off elevation counter for his initial reading. He must confirm or refine the reading with the quadrant before subtracting 2.3.			
1. Measured the elevation to the DAP by placing gunner's quadrant on quadrant seats and leveling longitudinal bubble of gunner's quadrant (must not move tube).	____	____	_____
2. Subtracted 2.3 mils from elevation measured with gunner's quadrant.	____	____	_____
3. Placed revised setting on gunner's quadrant.	____	____	_____
4. Depressed tube until longitudinal bubble of gunner's quadrant was centered.	____	____	_____
5. Centered cross-level bubble, if required.	____	____	_____
6. Checked gunner's quadrant after centering cross-level bubble (if sight was adjusted in PM5).	____	____	_____
7. Alined the telescope with the gun tube by turning the elevation adjusting screw while sighting through direct fire telescope.	____	____	_____
8. Sight picture had 0-mil line alined on the DAP.	____	____	_____
9. Completed boresight within three minutes.	____	____	_____

TIME		Initial	Retest
Minutes to boresight:	First Test	_____	_____
	Repetition 2	_____	_____
	Repetition 3	_____	_____

PM NO-GO Repetition 2 _____

PM NO-GO Repetition 3 _____

MEASURE THE QUADRANT WITH THE RANGE QUADRANT
SET/LAY THE CANNON FOR QUADRANT WITH RANGE QUADRANT (M198)
SIGHT ON A TARGET WITH DIRECT FIRE TELESCOPE

Equipment Required To Set Up Station and Conduct Test

M198 howitzer
M138 direct fire telescope

Procedures To Set Up Station

1. Take tube out of travel lock and change elevation of gun.

2. Insure elevation correction counter reads zero (00).

3. Select or position a target at range of 600-900 meters.

Procedures Performed Before Testing Each Soldier

Measure Quadrant

1. Set cannon at an elevation different from previous test (if any).

2. Level all bubbles without moving the tube.

3. Record the quadrant from the elevation counter.

4. Without moving the tube, change number in elevation counter and off-center the longitudinal and cross-level bubbles.

Set/Lay for Quadrant

5. Off-center the cross-level bubble.

Sight on Target

6. No change required.

Procedures To Conduct and Score Test

1. Give the measure quadrant test first, followed by set quadrant, then sight on target.

2. For the measure quadrant test, you do not need to check whether the bubbles are centered, just whether the soldier turned the knobs.

3. For the set quadrant test you do need to check the longitudinal and cross-level bubbles. Each bubble must be within or on the scribe marks.

4. For the sight on target test, alternate 700 and 900 meters as the range element. These two ranges will require the soldier to determine the midpoint of listed mil conversions.

Scorer: _____ Soldier: _____

Date: _____

SCORESHEET

MEASURE QUADRANT WITH THE RANGE QUADRANT (M198)

INSTRUCTIONS TO SOLDIER: At this station you will act as the Assistant Gunner and measure quadrant using the range quadrant. You must measure and announce the quadrant within 15 seconds. Ready. Measure the quadrant.

	QUADRANTS	
	Initial	Retest
First	_____	_____
Second	_____	_____
Third	_____	_____

PERFORMANCE MEASURES	GO	NO-GO	COMMENTS
1. Centered the longitudinal and cross-level bubbles without moving the tube.	____	____	_____
2. Announced the quadrant within 1 mil of recorded quadrant.	____	____	_____
3. Announced quadrant within 15 seconds of command.	____	____	_____

TIME		Initial	Retest
Seconds to measure quadrant:	First Test	_____	_____
	Repetition 2	_____	_____
	Repetition 3	_____	_____

PM NO-GO Repetition 2 _____

PM NO-GO Repetition 3 _____

Scorer: _____ Soldier: _____

Date: _____

SCORESHEET

SET/LAY CANNON FOR QUADRANT WITH RANGE QUADRANT (M198)

INSTRUCTIONS TO SOLDIER: On this test you will act as the Assistant Gunner. You will set the cannon for quadrant using the range quadrant. You must set off the quadrant within 30 seconds. Ready.

QUADRANT _____ (Give soldier quadrant from 30-50 mils from previous setting)

PERFORMANCE MEASURES	GO	NO-GO	COMMENTS
1. Repeated command QUADRANT _____.	_____	_____	_____
2. Set announced quadrant on the elevation counter before centering bubbles.	_____	_____	_____
3. Centered the longitudinal bubble by elevating or depressing the cannon tube.	_____	_____	_____
4. Centered the cross-level bubble using the cross leveling knob after centering the longitudinal bubble.	_____	_____	_____
5. Announced SET.	_____	_____	_____
6. Set quadrant within 30 seconds.	_____	_____	_____

TIME		Initial	Retest
Time to set cannon for quadrant:	First Test	_____	_____
	Repetition 2	_____	_____
	Repetition 3	_____	_____

PM NO-GO Repetition 2 _____

PM NO-GO Repetition 3 _____

Scorer: _____ Soldier: _____

Date: _____

SCORESHEEET

SIGHT ON A TARGET WITH THE DIRECT FIRE TELESCOPE (M198)

INSTRUCTIONS TO SOLDIER: At this station you will act as the Assistant Gunner and engage a direct fire target. You have 15 seconds to perform this task after the initial fire command is given. Ready.

NOTE TO SCORER: Give fire command: "TARGET TRUCK (RIGHT/LEFT) FRONT, SHELL, HE, CHARGE-7 WB, FUZE QUICK, RANGE ____ METERS, FIRE AT WILL."

PERFORMANCE MEASURES	GO	NO-GO	COMMENTS
1. Repeated announced range from the fire command.	____	____	_____
2. Elevated or depressed the tube until the mil line corresponding to the range to target was on center mass of target.	____	____	_____
3. Repeatedly announced SET until command FIRE was given.	____	____	_____
NOTE TO SCORER: Give soldier time to announce more than once. Stop the time when soldier announces SET, but give him time to repeat SET before you announce FIRE.	____	____	_____
4. Sighted on target within 15 seconds.	____	____	_____

TIME		Initial	Retest
Seconds to sight on direct fire target (from range element):	First Test	_____	_____
	Repetition 2	_____	_____
	Repetition 3	_____	_____

PM NO-GO Repetition 2 _____

PM NO-GO Repetition 3 _____

DISASSEMBLE/ASSEMBLE BREECH MECHANISM

Equipment Required To Set Up and Conduct Test

M198 howitzer
Flattipped screwdriver
1/2-inch square drive socket wrench
TM9-1025-211-10 with change 2

Procedures To Set Up Station

1. Check to insure breech is operational.

2. Lay screwdriver, socket wrench, and TM within reach of the soldier.

Procedures To Be Performed Before Testing Each Soldier

1. Return breech mechanism to operational status if needed.

2. Lay out tools for soldier.

Procedures To Conduct Test

1. The soldier must open the TM to the section on breech maintenance before he begins to disassemble the breech. Give him about one minute to locate the section. If he does not locate it, show him how to find it in the index. He does not have to look at the TM after finding the section.

2. Start the time for disassembly when the soldier finds the section in the TM.

3. The only component that should be disassembled in this test is the obturator. If the soldier starts to disassemble any other component, tell him, "You do not have to disassemble that component. Continue with disassembly." (No NO-GO.)

4. For PM 3 (removing the firing mechanism housing assembly), the soldier may need to use the screwdriver and socket wrench. If he tries and is unable to do those steps by hand, tell him to use the tools. Do not score him NO-GO if he is able to do the steps with the tools.

5. The soldier may become confused with the format of the TM. If he cannot do the first step for a component and is not on the correct page, mark the PM NO-GO, show him the correct page, and put "TM" under COMMENTS. If he still cannot do the step, tell him how to do the step and put "prompt" under COMMENTS. If he still cannot do the step, show him how and put "demo" under COMMENTS.

Scorer: _____ Soldier: _____

Date: _____

SCORESHEET

DISASSEMBLE/ASSEMBLE BREECH MECHANISM

INSTRUCTIONS TO SOLDIER: For this test you will disassemble and assemble the breech mechanism. First disassemble the breech and obturator. You have six minutes for disassembly. Begin.

PERFORMANCE MEASURES	GO	NO-GO	COMMENTS
1. Opened TM to section for breech maintenance (p. 3-34 thru 3-46).	____	____	_____
2. Removed the M35 firing mechanism.	____	____	_____
3. Removed the firing mechanism block.	____	____	_____
4. Removed the firing mechanism housing assembly.	____	____	_____
5. Removed the obturator spindle assembly.	____	____	_____
6. Disassembled obturator into: disk, rear split ring, inner ring, obturator pad, and front split ring.	____	____	_____
7. Completed disassembly in six minutes.	____	____	_____

TIME		Initial	Retest
Minutes to disassemble:	First Test	_____	_____
	Repetition 2	_____	_____
	Repetition 3	_____	_____

PM NO-GO Repetition 2 _____

PM NO-GO Repetition 3 _____

SCORESHEET (Cont'd.)

DISASSEMBLE/ASSEMBLE BREECH MECHANISM

PERFORMANCE MEASURES	GO	NO-GO	COMMENTS
INSTRUCTIONS TO SOLDIER: Now assemble the breech mechanism. You have eight minutes.			
8. Assembled obturator so that split rings were 180° apart.	____	____	____
9. Placed obturator spindle assembly into breechblock so arrow on obturator lined up with arrow on breechblock.	____	____	____
NOTE TO SCORER: Allow about two minutes for the soldier to get the assembly in position. If not lined up, show him in the TM how assembly should be installed. Score PM 9 NO-GO.			
10. Tightened assembly by turning assembly counterclockwise (in direction of arrow on breechblock.	____	____	____
11. Closed breechblock assembly.	____	____	____
12. Pushed cartridge extractor towards obturator spindle assembly.	____	____	____
13. Rotated breechblock assembly until slot was horizontal and extractor was against obturator spindle assembly.	____	____	____
14. Installed firing mechanism block assembly.	____	____	____
15. Placed firing mechanism in block assembly and turned it 1/4 turn clockwise while pressing in.	____	____	____
16. Slid firing mechanism block assembly to the right.	____	____	____
17. Tested action of firing pin by pushing and releasing pin.	____	____	____
18. Completed assembly within eight minutes.	____	____	____

TIME		Initial	Retest
Minutes to assemble:	First Test	____	____
	Repetition 2	____	____
	Repetition 3	____	____

PM NO-GO Repetition 2 _____

PM NO-GO Repetition 3 _____

APPENDIX B

DUTY POSITION AND TASK EXPERIENCE QUESTIONNAIRE
(FOR TESTED SOLDIERS)

RECENCY FREQUENCY QUESTIONNAIRE

NAME _____ SSN _____ GRADE _____

DATE OF OSUT GRADUATION _____

BATTERY _____ SECTION _____

DUTY POSITION: Cannoneer 2-7 _____ Assistant Gunner _____

#1 Cannoneer _____ Other _____

Have you received any training as an assistant gunner? YES NO

Have you been assistant gunner during live fire exercises? YES NO

How many times? 1-5, 6-10, 11-15, 16+

When was last time? _____ weeks ago

	TASK	PERFORMED IN OSUT		TESTED IN OSUT		INDIV. TRAINING WITH SUPERVISOR		LECTURE OR DEMO (NOT PERFORMED)		CREW DRILL OR RSOP		LIVE FIRE	
						Times	Last	Times	Last	Times	Last	Times	Last
1.	Emplace and recover aiming posts	Y	N	Y	N	1-5 6-10 11-15 16+	_____	1-5 6-10 11-15 16+	_____	1-5 6-10 11-15 16+	_____		
2.	Emplace and recover collimator	Y	N	Y	N	1-5 6-10 11-15 16+	_____	1-5 6-10 11-15 16+	_____	1-5 6-10 11-15 16+	_____		
3.	Disassemble breech mechanism	Y	N	Y	N	1-5 6-10 11-15 16+	_____	1-5 6-10 11-15 16+	_____	1-5 6-10 11-15 16+	_____	1-5 6-10 11-15 16+	_____
4.	Assemble breech mechanism	Y	N	Y	N	1-5 6-10 11-15 16+	_____	1-5 6-10 11-15 16+	_____	1-5 6-10 11-15 16+	_____	1-5 6-10 11-15 16+	_____
5.	Prepare position to receive howitzer	Y	N	Y	N	1-5 6-10 11-15 16+	_____	1-5 6-10 11-15 16+	_____	1-5 6-10 11-15 16+	_____		
6.	Disassemble and assemble M60 machinegun	Y	N	Y	N	1-5 6-10 11-15 16+	_____	1-5 6-10 11-15 16+	_____			1-5 6-10 11-15 16+	_____
7.	Prepare separate loading ammunition for firing	Y	N	Y	N	1-5 6-10 11-15 16+	_____	1-5 6-10 11-15 16+	_____	1-5 6-10 11-15 16+	_____		

	TASK	PERFORMED IN OSUT		TESTED IN OSUT		INDIV. TRAINING WITH SUPERVISOR		LECTURE OR DEMO (NOT PERFORMED)		CREW DRILL OR RSOP		LIVE FIRE	
						Times	Last	Times	Last	Times	Last	Times	Last
7.	Measure quadrant with range quadrant	Y	N	Y	N	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____
8.	Set/Lay cannon for quadrant with range quadrant	Y	N	Y	N	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____
9.	Sight on target with direct fire telescope	Y	N	Y	N	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____
10.	Perform gunner's quadrant micrometer test	Y	N	Y	N	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____
11.	Boresight direct fire telescope using DAP (with gunner's quadrant)	Y	N	Y	N	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____

RECENCY FREQUENCY QUESTIONNAIRE - AUGUST 83

NAME _____ SSN _____ GRADE _____

BATTERY _____ SECTION _____ SECTION CHIEF _____

Date Last ARTEP _____ Date Last Live Fire _____ Date Last Section Drill _____

Primary Duty Position. (Circle one only)

G A/G 1 2 3 4 5 6 7 Dvr Other_____

Has your primary duty position changed since you were tested in June? Yes No
If yes, what was your duty position in June?

Have you been cross trained in other duty positions since you were tested in June? Yes No

(Circle the positions you have been cross trained in)

G A/G 1 2 3 4 5 6 7 Dvr Other_____

Date Last Cross Trained_____

Additional Duties Performed Last 2 Months. (Circle one or more)

None G A/G 1 2 3 4 5 6 7 Dvr Other_____

Primary Duty Position Last ARTEP. (Circle one only)

G A/G 1 2 3 4 5 6 7 Dvr Other_____

Duties Performed Last Live Fire Exercise. (Circle one or more)

G A/G 1 2 3 4 5 6 7 Dvr Other_____

Duties Performed Last Period of Section Training. (Circle one or more)

G A/G 1 2 3 4 5 6 7 Dvr Other_____

Additional Duties Performed Last 2 Months. (Circle one or more)

a. Nuclear Assembler
b. Security Guard
c. RTO
d. Gun Guide
e. Ammo Handler
f. Arty Mechanic
g. Heavy Vehicle Driver
h. Light Vehicle Driver
i. Other _____
j. None

	TASK	PERFORMED SINCE LAST TEST		INDIV. TRAINING WITH SUPERVISOR		LECTURE OR DEMO (NOT PERFORMED)		CREW DRILL OR RSOP		ARTEP		LIVE-FIRE (NON-ARTEP	
				Times	Last	Times	Last	Times	Last	Times	Last	Times	La
1.	Emplace and recover aiming posts	Y	N	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 15+	___
2.	Emplace and recover collimator	Y	N	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	___
3.	Disassemble breech mechanism	Y	N	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	___
	Assemble breech mechanism	Y	N	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	___
4.	Prepare position to receive howitzer	Y	N	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	___
5.	Disassemble and assemble M60 machinegun	Y	N	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	___
6.	Prepare separate loading ammunition for firing	Y	N	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	___

	TASK	PERFORMED SINCE LAST TEST		INDIV. TRAINING WITH SUPERVISOR		LECTURE OR DEMO (NOT PERFORMED)		CREW DRILL OR RSOP		ARTEP		LIVE-FIRE (NON-ARTEP)	
				Times	Last	Times	Last	Times	Last	Times	Last	Times	Las
7.	Measure quadrant with range quadrant	Y	N	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____
8.	Set/Lay cannon for quadrant with range quadrant	Y	N	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____
9.	Sight on target with direct fire telescope	Y	N	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____
10.	Perform gunner's quadrant micrometer test	Y	N	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____
11.	Boresight direct fire telescope using DAP (with gunner's quadrant)	Y	N	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____

RECENCY FREQUENCY QUESTIONNAIRE - NOVEMBER 83

NAME _____ SSN _____ GRADE _____

BATTERY _____ SECTION _____ SECTION CHIEF _____

Date Last ARTEP _____ Date Last Live Fire _____ Date Last Section Drill _____

Primary Duty Position. (Circle one only)

G A/G 1 2 3 4 5 6 7 Dvr Other_____

Has your primary duty position changed since you were tested in June? Yes No
If yes, what was your duty position in August?

Have you been cross trained in other duty positions since you were tested in August? Yes No

(Circle the positions you have been cross trained in)

G A/G 1 2 3 4 5 6 7 Dvr Other_____

Date Last Cross Trained_____

Additional Duties Performed Last 2 Months. (Circle one or more)

None G A/G 1 2 3 4 5 6 7 Dvr Other_____

Primary Duty Position Last ARTEP. (Circle one only)

G A/G 1 2 3 4 5 6 7 Dvr Other_____

Duties Performed Last Live Fire Exercise. (Circle one or more)

G A/G 1 2 3 4 5 6 7 Dvr Other_____

Duties Performed Last Period of Section Training. (Circle one or more)

G A/G 1 2 3 4 5 6 7 Dvr Other_____

Additional Duties Performed Last 2 Months. (Circle one or more)

a. Nuclear Assembler
b. Security Guard
c. RTO
d. Gun Guide
e. Ammo Handler
f. Arty Mechanic
g. Heavy Vehicle Driver
h. Light Vehicle Driver
i. Other _____
j. None

	TASK	PERFORMED SINCE LAST TEST		INDIV. TRAINING WITH SUPERVISOR		LECTURE OR DEMO (NOT PERFORMED)		CREW DRILL OR RSOP		ARTEP		LIVE-FIRE (NON-ARTEP)	
				Times	Last	Times	Last	Times	Last	Times	Last	Times	La:
1.	Emplace and recover aiming posts	Y	N	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____
2.	Emplace and recover collimator	Y	N	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____
3.	Disassemble breech mechanism	Y	N	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____
	Assemble breech mechanism	Y	N	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____
4.	Prepare position to receive howitzer	Y	N	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____
5.	Disassemble and assemble M60 machinegun	Y	N	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____
6.	Prepare separate loading ammunition for firing	Y	N	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____

	TASK	PERFORMED SINCE LAST TEST		INDIV. TRAINING WITH SUPERVISOR		LECTURE OR DEMO (NOT PERFORMED)		CREW DRILL OR RSOP		ARTEP		LIVE-FIRE (NON-ARTEP)	
				Times	Last	Times	Last	Times	Last	Times	Last	Times	Las
7.	Measure quadrant with range quadrant	Y	N	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	___
8.	Set/Lay cannon for quadrant with range quadrant	Y	N	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	___
9.	Sight on target with direct fire telescope	Y	N	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	___
10.	Perform gunner's quadrant micrometer test	Y	N	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	___
11.	Boresight direct fire telescope using DAP (with gunner's quadrant)	Y	N	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	___

RECENCY FREQUENCY QUESTIONNAIRE - JANUARY 84

NAME _____ SSN _____ GRADE _____

BATTERY _____ SECTION _____ SECTION CHIEF _____

Date Last ARTEP _____ Date Last Live Fire _____ Date Last Section Drill _____

Date Last Tested on This Project: (Circle one) June August November

Primary Duty Position. (Circle one only)

G A/G 1 2 3 4 5 6 7 Dvr Other_____

Has your primary duty position changed since you were last tested? Yes No
If yes, what was your duty position when last tested?

Have you been cross trained in other duty positions since you were last tested? Yes No

(Circle the positions you have been cross trained in)

G A/G 1 2 3 4 5 6 7 Dvr Other_____

Date Last Cross Trained_____

Additional Duties Performed Last 2 Months. (Circle one or more)

None G A/G 1 2 3 4 5 6 7 Dvr Other_____

Primary Duty Position Last ARTEP. (Circle one only)

G A/G 1 2 3 4 5 6 7 Dvr Other_____

Duties Performed Last Live Fire Exercise. (Circle one or more)

G A/G 1 2 3 4 5 6 7 Dvr Other_____

Duties Performed Last Period of Section Training. (Circle one or more)

G A/G 1 2 3 4 5 6 7 Dvr Other_____

Additional Duties Performed Last 2 Months. (Circle one or more)

a. Nuclear Assembler
b. Security Guard
c. RTO
d. Gun Guide
e. Ammo Handler
f. Arty Mechanic
g. Heavy Vehicle Driver
h. Light Vehicle Driver
i. Other _____
j. None

	TASK	PERFORMED SINCE LAST TEST		INDIV. TRAINING WITH SUPERVISOR		LECTURE OR DEMO (NOT PERFORMED)		CREW DRILL OR RSOP		ARTEP		LIVE-FIRE (NON-ARTEP)	
				Times	Last	Times	Last	Times	Last	Times	Last	Times	Last
1.	Emplace and recover aiming posts	Y	N	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____
2.	Emplace and recover collimator	Y	N	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____
3.	Disassemble breech mechanism	Y	N	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____
	Assemble breech mechanism	Y	N	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____
4.	Prepare position to receive howitzer	Y	N	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____
5.	Disassemble and assemble M60 machinegun	Y	N	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____
6.	Prepare separate loading ammunition for firing	Y	N	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____

TASK	PERFORMED SINCE LAST TEST		INDIV. TRAINING WITH SUPERVISOR		LECTURE OR DEMO (NOT PERFORMED)		CREW DRILL OR RSOP		ARTEP		LIVE-FIRE (NON-ARTEP)	
			Times	Last	Times	Last	Times	Last	Times	Last	Times	Last
7. Measure quadrant with range quadrant	Y	N	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____
8. Set/Lay cannon for quadrant with range quadrant	Y	N	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____
9. Sight on target with direct fire telescope	Y	N	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____
10. Perform gunner's quadrant micrometer test	Y	N	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____
11. Boresight direct fire telescope using DAP (with gunner's quadrant)	Y	N	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____	1-5 6-10 11-15 16+	____

APPENDIX C

DUTY POSITION QUESTIONNAIRES
(FOR SUPERVISORS)

JOB BOOK RECENCY

SECTION _____

BATTERY _____

DATE: LAST ARTEP _____ LAST LIVE FIRE _____ LAST SECTION DRILL _____

	NAME	NAME	NAME	NAME
I. Primary Duty Position (Circle one only)	G A/G Dvr 1 2 3 4 5 6 7 Other	G A/G Dvr 1 2 3 4 5 6 7 Other	G A/G Dvr 1 2 3 4 5 6 7 Other	G A/G D 1 2 3 4 5 6 Other
II. Additional Duties Performed Past 2 Mo. (Circle all that apply)	G A/G Dvr 1 2 3 4 5 6 7 Other	G A/G Dvr 1 2 3 4 5 6 7 Other	G A/G Dvr 1 2 3 4 5 6 7 Other	G A/G D 1 2 3 4 5 6 Other
III. Primary Duty Position Last ARTEP (Circle one only)	G A/G Dvr 1 2 3 4 5 6 7 Other	G A/G Dvr 1 2 3 4 5 6 7 Other	G A/G Dvr 1 2 3 4 5 6 7 Other	G A/G D 1 2 3 4 5 6 Other
IV. Duties Performed Last Live Fire Exercise (Circle one or more)	G A/G Dvr 1 2 3 4 5 6 7 Other	G A/G Dvr 1 2 3 4 5 6 7 Other	G A/G Dvr 1 2 3 4 5 6 7 Other	G A/G D 1 2 3 4 5 6 Other
V. Duties Performed Last Section Drill (Circle one or more)	G A/G Dvr 1 2 3 4 5 6 7 Other	G A/G Dvr 1 2 3 4 5 6 7 Other	G A/G Dvr 1 2 3 4 5 6 7 Other	G A/G D 1 2 3 4 5 6 Other
VI. Other Duties Performed Past 2 Mo. (Circle all that apply) a. Nuclear Assembler b. Security Guard c. RTO d. Gun Guide e. Ammo Handler f. Arty Mechanic g. Heavy Vehicle Dvr h. Light Vehicle Dvr i. Other	a b c d e f g h i	a b c d e f g h i	a b c d e f g h i	a b c d e f g h i

SECTION	NAME	Aiming Post	Collimator	Prep Position	Prep Ammo	Dis/Assem M60	Meas Quadrant	Direct Fire	Lay for Quadrant	Boresight	Micrometer Test	Dis/Assem Breech

APPENDIX D

SELF REPORT DATA

SELF REPORT DATA

At each test, questions were asked of each soldier regarding the last time any of the tasks was performed (recency/frequency). For these self reports we asked for the most recent exposure to each task as a result of individual training, lectures, crew drill, ARTEP, and Live Fire exercises. Soldiers were also asked to supply background information regarding their primary duty position, positions in which they were crosstrained, and duties performed in the preceeding two months. Additionally, between each of the retention tests, Section Chiefs were asked to complete a questionnaire indicating last ARTEP, Live Fire, Section Drill and duties performed by each soldier under their supervision. Job Book data for each soldier were also requested. The latter provided the date of the last individual training for each soldier on each task. We were unable to retrieve these data for every soldier; however, we were successful for the majority of cases. The following matrix shows the number of soldiers for whom data were collected from these sources at each retention test.

Source	Retention 1	Retention 2	Retention 3
Section Chief (or Job Book)			
Background	50	81	0
Recency/Frequency	51	61	111
Self Report			
Background	60	89	114
Recency/Frequency	60	89	114

In an effort to measure the accuracy of the self reports of the soldiers, we compared these to the information collected from the Section Chiefs. We measured agreement between the two in the following manner: For questions regarding duty positions, we took only exact matches. That is, if a Section Chief listed a soldier's primary duty position as Assistant Gunner, and the soldier reported it as Gunner, this was coded as a no match. We allowed more flexibility on questions involving dates. Section Chiefs provided exact dates; soldiers usually responded with more general estimates, such as "six weeks

prior to testing." We considered a range of plus or minus two weeks as acceptable agreement. We found a high level of agreement between Section Chiefs and self reports for primary duty position and crosstraining positions; at each retention test there was at least 80% agreement. There was less agreement between these sources regarding duties performed in the two months preceeding the test; on the average, agreement was only 45% on these types of questions.

We were particularly interested in comparing the most recent performance of specific tasks. Only individual training data (Job Book vs. self report) were available on a task-by-task basis. Table D.1 shows the percentage of agreement between these two sources. Retention 2 showed the lowest average percent agreement (22.7%) of the three test periods. However, in only five instances did agreement equal or exceed 50%. At Retention 1 and Retention 3 we found that the average agreement was 44.6% and 42.6%, respectively. When there were disagreements regarding whether or not tasks were performed since the last test, data from the Job Book were slightly more likely to indicate task performances than were the soldiers.

After reviewing these results, we decided to use Section Chief and Job Book data in our statistical analyses. If these data were not available, self reports were edited and then used. The editing consisted of first examining the recency dates within each battery. For many of the tasks, we found that the soldiers in a given battery practiced together; thus, if there was a common date of task performance, that value was assigned to all soldiers in that battery. Also, where soldiers reported doing a test prior to their last testing, that value was scored as "did not perform".

Table D.1
Percentage Agreement Between Section Chief Data and Soldier Self Reports

Tasks	Retention 1 N	Retention 1 %	Retention 2 N	Retention 2 %	Retention 3 N	Retention 3 %
Measure Quadrant	34	52.9	54	25.9	108	45.3
Set/Lay Cannon	35	45.7	54	20.4	107	48.6
Sight Target	34	26.5	54	24.1	106	48.1
Micrometer Test	26	42.3	32	34.4	41	19.5
Boresight Telescope	33	24.2	54	22.2	101	46.5
Emplace/Recover Aiming Posts	34	26.5	57	19.3	109	49.5
Emplace/Recover Collimator	34	52.9	57	19.3	108	49.1
Select Ammunition	34	55.9	57	14.0	108	51.9
Disassemble/Assemble M60 Machinegun	34	44.1	58	20.7	107	38.3
Disassemble/Assemble Breech	34	50.0	57	26.3	107	43.9
Install Stakes/ Establish Communication	27	48.1	57	22.8	44	29.6
$\bar{X}$		44.6		22.7		42.6